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THE RELATIVE VALUES FOR EIGHTH-GRADE GENERAL SCIENCE OF TOPICS AND EXPERIMENTS IN THE AREA MAGNETISM AND ELECTRICITY FOR THE DEVELOPMENT OF RELATED SCIENTIFIC PRINCIPLES

Submitted by

Ida May Lynch

(B.S. in Ed., Boston University, 1935)

In partial fulfillment of requirements for

the degree of Master of Education

April, 1947

First Reader: Vaden W. Miles, Assistant Professor of Education

Second Reader: Charles E. Stratton, Professor of Science and Mathematics

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Professor Vaden W. Miles of Boston University directed this study and validated the assignment of topics and experiments to designated principles.

The evaluators from the Seminar in Science Education, Boston University, 1946-47, were: Mr. Angelo L. Annacone, of Roslindale High School, Roslindale, Mass., Mr. Alfred J. Brudzynski, formerly of Salem High School, Salem, Mass., Mr. Manning S. Case, of Newington Junior-Senior High School, Newington, Conn., Mr. David I. Hoyle, of Melrose High School, Melrose, Mass., and Mr. Philip Wogan, Beverly, Mass.

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CHAPTER I

SURVEY OF THE RELATED LITERATURE

INTRODUCTION

For the purpose of evaluating the objectives of science teaching an analysis was made in 1932 of the objectives found in fifty-one general science courses of study published since 1925.[1] The results, which revealed a wide divergence of opinion as to what a science objective is, are interesting as a diagnosis of the objectives found in the courses of study then in use. Principles as such were not stated as objectives in any of the courses of study.

In that same year, 1932, a report of a committee of the National Society for the Study of Education was published as the Thirty-first Yearbook of that Society under the title A Program for Teaching Science.[2] The committee,[3] after defining the aim of education as Life Enrichment through Participation in a Democratic Social Order, goes

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[1] Instruction in Science, Bulletin, 1932, No. 17. Monograph No. 22, United States Department of the Interior, Office of Education, Washington, D. C.

[2] A Program for Teaching Science, Thirty-first Yearbook of the National Society for the Study of Education, Part I, Bloomington, Illinois: Public School Publishing Company, 1932.

[3] Ibid., p. 42.

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on to explain that

> Life enrichment is in part, and in large part, developed from the understanding of principles and generalizations that ramify into human experience. These principles and generalizations are functional in that they furnish a background for intelligent response to stimuli that recur in common unspecialized experience. The understanding of principles and generalizations comes from the association of ideas that are developed from experiences. These understandings are products of the activities of the school if the ideas from which they are developed are products of classroom activities. It is clear then, that the school will contribute to life enrichment if its activities are of the kind from which ideas may be developed and if the ideas may in turn be associated with principles and generalizations that are woven into human experience.

In 1938 the Report of the Committee on the Function of Science in General Education[4] of the Commission on the Secondary School Curriculum of the Progressive Education Association stated:

> The purpose of general education is to meet the needs of individuals in the basic aspects of living in such way as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society. Needs arise and work themselves out in living, dynamic events which can only be described as interactions between the individual and the social situation.

The committee believes that the needs of the adolescent arise from an interaction between the individual and the social situation. The teacher, therefore, must be concerned with the total situation, including both the individual and his environment and should have for the aim

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[4]Progressive Education Association, Commission on Secondary School Curriculum, Science in General Education. pp. 23-25. New York: D. Appleton-Century Company, 1938.

of science instruction "interpretive understandings" that can be formulated in terms of the generalizations which when learned become incorporated in the individual as adaptations in personality with resulting intelligent behavior.

These three reports have helped teachers of science to develop their views of the function of science in general education, with the emphasis on the functional understanding of scientific principles.

SURVEY OF LITERATURE RELATING TO THE DETERMINATION OF PRINCIPLES AS OBJECTIVES OF SCIENCE TEACHING

The Fifth Yearbook of the Department of Superintendence of the National Education Association[5] says:

> Our knowledge of science to be of the largest service must be in the form of principles and laws. Application of our knowledge of science to problem situations is a deductive process. Faced by a difficulty we cast about for the law or principle that applies to it and thus reach a solution. It would seem that the design of the course in science for the junior high school should enable the pupils to have experiences with an attainment of knowledge of those laws and principles that are socially worthwhile, and should provide much drill in applying them to life situations.

This problem has been recognized for the past twenty years and there has been an increasing focusing of attention on the importance of principles as objectives in science instruction. One of Downing's[6] early studies, made

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[5] The Junior High School Curriculum, Fifth Yearbook, Department of Superintendence, National Education Association, p. 150. Washington, D. C.: National Education Association, 1927.

[6] Elliot R. Downing, Teaching Science in the Schools, p. 53. Chicago: University of Chicago Press, 1925.

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in 1925, formulated these three steps for the solving of a scientific problem:

(1) accumulation of facts
(2) discovery of the relation and sequence of such facts reduced to generalizations
(3) discovery of the approximate causes that underlie such laws or principles.

In 1928 the position of principles in general science textbooks was one of minor importance according to the findings of the study made by Heinemann[7] who in the analysis of twenty such books found only ninety-three principles. These ninety-three principles were given little spatial importance, only a little more than twelve percent of all reading space. Heinemann recommended placing the teaching emphasis on a small number of principles with multiple applications rather than on a large number of principles with few applications. As a criterion for a principle Heinemann defines a principle of science as a "statement of relationship frequently causal in nature between two facts."

In 1934, a list of ninety-six principles considered necessary in chemistry, physics and biology was drawn up by Downing[8] from a group of masters' theses written at the University of Chicago. These principles were classified and arranged in order of importance as determined by the amount of subject matter needed to make the principle intelligible.

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[7] Ailsie M. Heinemann, "A Study of General Science Textbooks," General Science Quarterly, XIII (Nov. 1928), 11-23.

[8] Elliot Rowland Downing, An Introduction to the Teaching of Science, pp. 39-48. Chicago: University of Chicago Press, 1934.

In 1934, Robertson[9] completed a study to determine the important principles of science which are suitable as goals of instruction in elementary science for grades I-VI, inclusive. Studies from both the University of Michigan and the University of Chicago were analyzed to secure lists of major and minor principles. According to Martin,[10] a group of teachers, members of the Department of Science, University of Michigan High School, in the Seminar in the Teaching of Science at the University of Michigan in 1934 used the following criteria employed by Robertson for selecting the principles: To be a principle a statement

> Must be a comprehensive generalization
> Must be true without exception within the limitations specifically stated
> Must be a clear statement of a process or interaction
> Must be capable of illustration so as to gain conviction
> Must not be a part of a larger principle
> Must not be a definition
> Must not deal with a specific substance or variety or with a limited group of substances or species

Of the 243 principles which the first group of teachers accepted as principles only 113 were later accepted by a second group of science teachers as being suitable as goals of instruction in the first six grades.

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[9] Martin L. Robertson, "The Selection of Science Principles Suitable as Goals of Instruction in the Elementary School," Science Education, XIX (February, 1935), 1-4; (April, 1935), 65-70.

[10] W. Edgar Martin, "A Chronological Survey of Research Studies on Principles as Objectives of Instruction in Science," Science Education, XXIX (February, 1945), 45-51.

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In the field of chemistry Pruitt[11] made a study to determine concepts and generalizations which are of most distinctive value to man in interpreting his environment. The study consisted of an extensive examination of over 50,000 pages of material, including several issues of three popular literary magazines, issues of four popular scientific magazines and one chemical journal, questions from three nationally known examinations, numerous books on various phases of science, particularly chemistry, and one year's issue of several newspapers for principles. By using the same criteria for a principle as were used previously by Robertson a final list of 135 generalizations related to chemistry was formulated with the principles arranged in the approximate order of their importance.

The criteria for a principle used by Wise[12] in his investigation of the principles of the physical sciences are as follows:

> To be a principle a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.
> It must be true without exception within limitations specifically stated.
> It must be capable of illustration.
> It must not be a definition.

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[11] Clarence Martin Pruitt, An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry. Doctor's dissertation, Teachers College, Columbia University, 1935. Distributed through Science Education. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphis: P. Blakiston's Son and Company, Inc., 1939, pp. 153-163.

[12] Harold E. Wise, "A Determination of the Relative Importance of Principles of Physical Science for General Education," Science Education, XXV (December, 1941), 371-379; XXVI (January, 1942), 8-12.

In an unpublished Doctor's dissertation, Wise[13] presents a list of principles arranged in the relative order of importance for general education grades I-XIV, inclusive. This list includes principles of chemistry, geology, and physics (including astronomy and meteorology) and is a composite list formulated from the lists of principles developed by Arnold, Hartman and Stephens, Pruitt, and Robertson.

In an investigation of the principles of biological sciences Martin[14] in 1944 used the following criteria for a principle:

(1) It must be a comprehensive generalization which resumes the widest possible range of facts within the domain of facts with which it is directly concerned. The facts resumed in the generalization must denote:
   a. Objects and/or events and the relation between them.
   b. Properties.

(2) It must be scientifically true. To satisfy this criterion:
   a. It must be verifiable; i.e. it must be stated so that it suggests, directly or indirectly, a definite operation of observations or experiments whereby its truth value can be tested or verified.
   b. It must be consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data (facts) relevant to it.

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[13] Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished Doctor's dissertation, University of Michigan, 1941.

[14] W. Edgar Martin, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education, XXIX (March, 1945), 100-105; XXIX (April-May, 1945), 152-163.

As a result of his study Martin produced a defensible list of 300 principles related to the field of the biological sciences.

In 1945 Fleish[15] analyzed ten textbooks of general science to determine which of a list of sixty principles were included in them. This list of principles was made as a result of a survey based upon the scientific interests of pupils in grades VII-XII inclusive in four Massachusetts communities and were formulated from questions contributed by the pupils.

The result of this study showed that most of the sixty principles were included in the textbooks analyzed but that they were not clearly stated.

When Jones[16] made a study to determine the principles of science found in seven ninth-grade textbooks of general science 146 principles were found to satisfy the following criteria:

A principle is a comprehensive generalization which
- Is stated positively and definitely
- Is true but with rare exceptions within the limitations set up by the statement
- Clearly states or implies a dynamic process or interaction
- Is demonstrable experimentally
- Is not merely a definition or a description
- Does not deal with specific substances or varieties
- Has meaning outside of the context

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[15] Sylvia Fleish, The Formulation of the Science Principles That Should Become the Objectives of General Science Teaching in the Junior High School. Unpublished Master's thesis, Boston University, 1945.

[16] Ruth V. Jones, A Study of the Principles of Science Found in Ninth Grade Textbooks of General Science. Unpublished Master's thesis, University of Michigan, 1946.

Jones also found a wide divergence in the number and selection of science principles included in the seven textbooks of general science.

In a lecture given at Belmont, Massachusetts in 1946, Craig[17] pointed out the value of science in the elementary curriculum as an aid in the development of desirable social behavior. He felt that the science teacher should work to get larger meanings and to have the pupil think in terms of larger principles.

SURVEY OF LITERATURE PERTAINING TO THE DETERMINATION OF THE EFFECTIVENESS OF PRINCIPLES IN TERMS OF RETENTION OF LEARNING

Reek[18] made an intensive survey of studies that showed the importance of teaching science principles in terms of retention of learning. These studies, which had been made by Tyler, Johnson, Wert, Frutchey, Haupt and Croxton, emphasized, according to Reek, the idea that the routine learning of unrelated facts was highly unsatisfactory in terms of retention. With such a finding, the experienced classroom teacher would wholeheartedly concur.

A further conclusion made by both Croxton and Haupt

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17 Gerald S. Craig, Science Workshop Day, December 10, 1946, Belmont Public Schools, Belmont, Massachusetts. (A mimeographed report by D. Justin McCarthy, Chairman Elementary Science Curriculum Committee, Belmont Public Schools.)

18 Doris Lucille Reek, A Study of the Principles of Science Found in Four Series of Textbooks of Elementary Science. Unpublished Master's thesis, University of Michigan, 1943.

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was reported by Reek. This was the statement that children can generalize on all levels of the elementary school and hence possess the ability to develop an understanding of principles if the necessary experiences are provided which are appropriate for their stage of maturity. This last point is one of the greatest importance and Reek recognizes that importance by the statement that children of all ages can generalize effectively if the problems are scaled to their interest, experiences and levels of maturity.

It is difficult to measure the functional understanding of principles by present inadequate measuring instruments. Croxton[19] makes it clear that the possession of knowledge and skill does not insure their functioning in the possessor's daily life. For example, a child may know the principle involved in a situation but that does not insure that he will use it. Croxton suggests informal discussion, writing, and reports from parents as possible means of appraising the functional outcomes of the teaching of principles of science.

Downing[20] suggests that the pupil be given such an understanding of the important principles of science that he will be skillful in the recall of such principles and in the application of them when necessary for the solution of his specific life-problems.

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[19] W. C. Croxton, Science in the Elementary School, P. 82. New York: McGraw-Hill Book Company, Inc., 1937.

[20] Elliot Rowland Downing, An Introduction to the Teaching of Science, p. 9. Chicago: University of Chicago Press, 1934.

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When Croxton[21] carried on his series of experiments that attempted to discover children's ability to generalize the results indicated that the superiority of junior high school pupils over those in intermediate grades in the matter of formulating and applying generalizations was little more than might be explained by their added experience.

SURVEY OF LITERATURE PERTAINING TO THE DETERMINATION OF EXPERIMENTS TO BE USED FOR DEVELOPING PRINCIPLES OF SCIENCE

One of the criteria for a principle according to the studies made by Wise, Martin and Jones is demonstrability. Educators are becoming increasingly conscious of the essentiality of laboratory demonstrations or laboratory work at all levels of education in science.

Beauchamp, Mayfield and West[22] define the ultimate objective of the learning process to be "the ability to use generalization in one's daily life." Caldwell and Curtis[23] also place considerable emphasis on scientific principles. One of the major objectives of science teaching as found in Everyday Science[24] is "to develop

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[21] W. C. Croxton, "Pupils' Ability to Generalize," School Science and Mathematics, XXXVI (June, 1936), 627-634.

[22] Wilbur L. Beauchamp, John C. Mayfield and Joe Young West, A Study-Book for Science Problems, p. iii. Chicago: Scott, Foresman and Company, 1941.

[23] Otis W. Caldwell and Francis D. Curtis, Teachers' Manual and Key to Accompany Everyday Science, p. 1. Boston: Ginn and Company, 1946.

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[24] Ibid. p. 1.

understandings of important scientific principles which the pupils may apply in their everyday lives."

There have been no research studies to determine experiments which may be used in developing the various principles of science at different grade levels for general education. However, the criterion of a principle which presupposes its demonstrability and the inclusion of the teaching of principles in the list of objectives of science teaching found in some textbooks suggest that there is some teaching of experiments to develop principles of science.

SUMMARY OF LITERATURE

The following general conclusions may be drawn from a review of the foregoing literature:

1. A major goal of instruction in science at all grade levels of general education is a functional understanding of scientific principles.

2. The writings of Downing as early as 1925 are responsible for the concept of generalizations as goals for science instruction in general education.

3. Robertson in 1934 laid the groundwork for the later accomplishments of Wise and Martin in compiling their defensible lists of physical science principles and biological principles, respectively.

4. The development of principles as one of the major objectives of a program of science teaching for general

education seems to be justified by the increase in the learner's ability to:

use principles of science in interpreting the experiences of everyday living
apply principles of science in the solution of practical problems
retain more effectively the learning of the principles of science than of factual matter pertaining to the same area of science.

5. Fleish and Jones found little agreement among the authors of textbooks of general science as to the number, selection and spatial importance of principles.

6. There have been no research studies to determine the experiments which may be used for developing the various principles of science at different grade levels.

THE PROBLEM OF THIS INVESTIGATION

This investigation is an attempt to determine for a general science course at the eighth-grade level a composite outline of subject-matter topics for the area Magnetism and Electricity, the experiments related to the respective topics, and the scientific principles an understanding of which should be increased by a discussion of designated topics and by the performance of designated experiments.

The subject-matter topics, experiments and principles to be included are those found in sixteen textbooks of general science and nine laboratory manuals or workbooks to accompany the textbooks, all of which are readily available from the publisher in December, 1946. Ten of the

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The subject-matter topics, experiments and principles to be included are those found in sixteen textbooks of general science and nine laboratory manuals or workbooks to accompany the textbooks, all of which are readily available from the publisher in December, 1945. Ten of the

textbooks written for the eighth-grade level are a part of a three-book series. The remaining six are general science textbooks intended for use in either grade seven, eight or nine but which are not a part of a three-book series and are not designated as being written for a particular grade level. Nine laboratory manuals to accompany the textbooks are also to be included.

It is undertaken in this investigation to make a defensible assignment to the principles of the experiments and topics the respective performance and discussion of which should help pupils of the eighth grade develop an understanding of the principles.

The principles, together with the related subject-matter topics and experiments that have been defensibly assigned to them, will then be validated by a specialist in the teaching of science.

STATEMENT OF THE PROBLEM

The purpose of this investigation is the determination of the science principles together with the related subject-matter topics and experiments for the area Magnetism and Electricity as found in nine laboratory manuals or workbooks of general science and sixteen textbooks of general science, ten of which are written specifically for the eighth-grade level, and the defensible assignment of those experiments and topics to the principles they represent.

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CHAPTER II

THE RESEARCH: PART I

INTRODUCTION

There are several parts of the research for the determination at the eighth-grade level of a composite outline of subject-matter topics for the area Magnetism and Electricity with related experiments and scientific principles, an understanding of which should be increased by a discussion of designated topics and by the performance of designated experiments. These several parts include: the selection and amassing of textual materials, the analyses of same and the validation and evaluation of the results.

STATEMENT OF THE PROBLEM

The purpose of this part of the investigation is to determine the inclusion and exclusion of the topics Magnetism and Electricity in sixteen textbooks of general science suitable for use at the eighth-grade level and to determine the spatial importance given by the authors to the topics Magnetism and Electricity.

DETERMINATION OF THE CRITERIA USED IN THE SELECTION OF TEXTUAL MATERIALS

In the selection of the textual materials in science to be used in this investigation the following criteria

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INTRODUCTION

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DETERMINATION OF THE CRITERIA USED IN THE SELECTION OF TEXTUAL MATERIALS

In the selection of the textual materials in science to be used in this investigation the following criteria

were used: To be used in this investigation the textbook in general science as well as its accompanying teacher's manual, laboratory manual or workbook must be one which

has been written specifically for use at the eighth-grade level; or
has been written for the junior-high-school level but for no designated grade level; or
has been written to present to teachers professionalized subject matter suitable for general science at the junior-high-school level;
has been published by a well-known publishing house;
was readily available from the publisher in December, 1946.

The following textual materials satisfied these five criteria and were obtained for use in this investigation:

Five textbooks of general science intended for use at the junior-high-school level but for no designated grade level
Ten textbooks of general science written specifically for the eighth-grade level
Nine laboratory manuals or workbooks to accompany the textbooks
Twelve teacher's manuals to accompany the textbooks
One textbook written to present to teachers professionalized subject matter suitable for general science at the junior-high-school level.

The textbooks selected were coded* thus:
a. Textbooks of general science for no designated grade level: A, C, D, E, F
b. Textbooks of general science written specifically for the eighth-grade level of general science: G, H, I, J, K, L, M, N, O, P
c. Textbook of professionalized subject matter suitable for general science at the junior-high-school level: B.

The textbook of professionalized subject matter suitable for general science at the junior-high-school level

*There is a special section of the bibliography for these coded textbooks.

will henceforth in this investigation be considered to be a textbook of general science for no designated grade level, grades VII-IX, inclusive.

Furthermore, for the purposes of this investigation, each textbook is hereafter referred to by its code letter. Whenever a laboratory manual or workbook to accompany any of these textbooks was available it was procured. Any analysis of a textbook included an analysis of such manual or workbook. For the purposes of this investigation the manual or workbook was considered an integral part of the textbook it accompanied in accordance with the author's apparent intent. Therefore, any finding whether made from the textbook or made from its accompanying laboratory manual or workbook was considered to be made from the textbook and was so credited.

ANALYSIS OF TEXTBOOKS FOR THE DETERMINATION OF THE GRADE PLACEMENT OF THE TOPICS MAGNETISM AND ELECTRICITY

Each of the sixteen textbooks of general science selected was examined for inclusion of the topics Magnetism and Electricity in a general science course at the eighth-grade level.

The code letters of the various textbooks were listed on a large card. As each piece of textual material was examined a notation was made on the card to show the inclusion or omission of the topic Magnetism and the inclusion or omission of the topic Electricity.

Table I which follows shows the results of the analysis of sixteen textbooks of general science for inclusion of the topics Magnetism and Electricity.

TABLE I

RESULTS OF AN ANALYSIS OF SIXTEEN TEXTBOOKS OF GENERAL SCIENCE FOR THE INCLUSION OF THE TOPICS MAGNETISM AND ELECTRICITY

	Textbooks of General Science						Textbooks of General Science for the Eighth-grade Level										
CODE*	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
MAGNETISM	*	*	*	*	*	*	*		*	*	*	*		*	*		13
ELECTRICITY	*	*	*	*	*	*	*	*	*	*	*	*		*	*		14

*Table I is read thus: The topics Magnetism and Electricity are found in Books A, B, C, D, E, F, G, I, J, K, L, N and O. The topic Magnetism is omitted in Books H, M and P. The topic Electricity is omitted in Books M and P.

TABLE I

RESULTS OF AN ANALYSIS OF SIXTEEN MATERIAL SCIENCE BOOKS FOR THE TOPICS MAGNETISM AND ELECTRICITY

	Textbooks of General Science for the Eighth-grade Level																
CONTENT*	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
MAGNETISM	*	*	*	*	*	*	*		*	*	*		*	*	*	*	12
ELECTRICITY	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	14

*Table I is read thus: Topics MAGNETISM and ELECTRICITY are found in books A, C, D, E, F, G, I, J, K, and P. The topic MAGNETISM is omitted in Books B, H, L, M, N, O, and P.

Findings Table I. Table I shows that both the topics Magnetism and Electricity were included in all six of the textbooks of general science. However, only seven of the ten textbooks of general science written specifically for the eighth-grade level included Magnetism, only eight included Electricity, and only seven included both Magnetism and Electricity. Two of the ten books included neither Magnetism nor Electricity.

ANALYSIS OF TEXTBOOKS FOR THE DETERMINATION OF THE SPATIAL IMPORTANCE GIVEN BY THE AUTHORS TO THE TOPICS MAGNETISM AND ELECTRICITY

In order to determine the spatial importance given by the authors to the topics Magnetism and Electricity a second examination of the textbooks was made. An exception was made in this examination to the practice of including accompanying workbooks and manuals in any consideration of a textbook for such inclusion would not be appropriate in a comparison of the page content devoted to the two topics in the various textbooks.

The total number of pages devoted to Magnetism and the total number of pages devoted to Electricity were first ascertained. Then, for purposes of comparison, the total number of pages that each textbook contained was noted. The results were presented in two ways, the number of pages devoted to each of the two topics and the percentage of the entire book as measured by pages that were so devoted.

Table II which follows shows the results of an analysis of sixteen textbooks of general science for spatial importance given to the topics Magnetism and Electricity.

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TABLE II

RESULTS OF AN ANALYSIS OF SIXTEEN TEXTBOOKS OF GENERAL SCIENCE FOR SPATIAL IMPORTANCE GIVEN TO THE TOPICS MAGNETISM AND ELECTRICITY

	Textbooks of General Science						Aver-age	Textbooks of General Science for the Eighth-grade Level										Aver-age	Average All Books
Code*	A	B	C	D	E	F		G	H	I	J	K	L	M	N	O	P		
Pages in textbook	815	551	754	675	664	495	659.0	496	565	500	452	542	596	578	352	554	502	513.7	568.2
Pages on Magnetism	2	18	3	7	5	6	6.8	14	0	2	2	1	1	0	4	9	0	3.3	4.6
Pages on Electricity	49	45	79	36	42	36	47.8	25	2	39	12	10	12	0	19	21	0	14.0	26.7
Total pages Magnetism and Electricity	51	63	82	43	47	42	54.7	39	2	41	14	11	13	0	23	30	0	17.3	31.3
Percent of total pages	6.3	11.4	10.9	6.4	7.1	8.5	8.3	7.9	0.4	8.2	3.1	2.0	2.2	0.0	6.5	5.4	0.0	3.4	5.5

*Table II is read thus: Of the 815 pages contained in Book A, a junior-high-school textbook of general science not written for a designated grade level, two pages are devoted to Magnetism and 49 pages to Electricity, making a total of 51 pages devoted to both. These 51 pages are 6.3 percent of the total number of pages in Book A.

TABLE II

RESULTS OF AN ANALYSIS OF SIXTEEN TEXTBOOKS ON SPATIAL RELATIONS OTHER THE TOPICS MAGNETISM AND ELECTRICITY

Code*	Textbooks of General Science								Textbooks of General Science - Junior High Level								Average Page-Count of All Books
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Pages in textbook	572	448	268	352	480	384	448	512	384	352	384	448	384	352	448	512	408.0
Pages on Magnetism	8	16	5	7	5	8	6	8	14	0	8	7	10	12	9	0	8.6
Total Pages on Magnetism and Electricity	48	48	24	36	48	32	48	64	28	32	32	28	32	28	32	0	32.7
Percent of Total Pages	8%	8%	9%	10%	10%	8%	11%	13%	7%	9%	8%	6%	8%	8%	7%	0%	8.3%

*Table II is read thus: Of the 8½ pages contained in Book A, a Junior-High-School textbook of General Science not written for a Parochial School, two pages are devoted to Magnetism and 48 pages to Electricity, making a total of 50 pages devoted to both. These 50 pages are 8.7 percent of the total number of pages in Book A.

Findings Table II. A comparison of six textbooks of general science suitable for use at the junior-high-school level but not written for a designated grade level with ten general science textbooks written specifically for the eighth-grade level shows the following averages, respectively: total pages devoted to Magnetism and Electricity, 54.7 pages or 8.3 percent of the total number of pages per book in contrast to 17.3 pages or 3.4 percent of the total number of pages per book. For all sixteen general science textbooks the averages show the total number of pages per book devoted to Magnetism and Electricity to be 31.3 pages or 5.5 percent of the 568.2 pages per book. Of the ten textbooks of general science written specifically for the eighth-grade level, one textbook included Electricity but not Magnetism, two textbooks included neither Magnetism nor Electricity, and the remaining seven included both Magnetism and Electricity.

CHAPTER III

THE RESEARCH: PART II

STATEMENT OF THE PROBLEM

This part of the investigation is concerned with the determination of the subject-matter topics for the area Magnetism and Electricity that were included in the selected textual materials, and the utilization of the data for the compilation of a composite topical outline that could be used at the eighth-grade level of instruction in science for the development of the topics Magnetism and Electricity.

ANALYSIS OF TEXTBOOKS FOR THE DETERMINATION OF SUBJECT-MATTER TOPICS FOR THE AREAS MAGNETISM AND ELECTRICITY

Each textbook and manual or workbook selected for this investigation was carefully examined for the third time. Each textbook was scrutinized for topics that

1. were stated as topics and sub-topics or
2. were implied in the context or in an illustration.

The sections of the texts that were devoted to the areas Magnetism and Electricity were read sentence by sentence to ascertain which subject-matter topics and sub-topics were contained therein.

Each subject-matter topic and sub-topic relating to either Magnetism or Electricity that was found in the

textual materials was copied on a white 3" x 6" file card in the upper right corner of which was the code letter of the book from which the topic was copied. The subject-matter topics and sub-topics stated as topics were considered to be those that were chapter, center and paragraph headings. Such topics were underlined after they had been copied on the white cards.

When the subject-matter topic was developed in the context but was not designated as a chapter, center or paragraph heading it was appropriately considered to be a topic or a sub-topic and was also recorded on the white card but was preceded by the letter I to denote that it was implied. Any topic that was implied by an illustration was recorded in the same manner. The same techniques were employed in the analysis of each of the sixteen textbooks and their accompanying laboratory manuals or workbooks. Whenever a topic was found expressed in similar fashion to one that was previously recorded, the topic that in the judgment of the investigator better expressed the idea was retained.

After all the textual materials had been examined and all the topics (both those that were stated as topics or sub-topics and those that were implied) had been recorded on the cards, the topics were then assembled, reworded wherever necessary for succinctness and clarity, and arranged in two composite outlines, one under the heading Magnetism and one under the heading Electricity. These composite outlines were then submitted to the specialist in the teaching of science directing the investigation. Any topics judged

by him as being incorrectly worded were reworded; those judged by him as being unsuitable for inclusion in the final outlines were omitted; those judged by him as being incorrectly placed in the outlines were changed as to position and those judged by him to be present more than once even though under different connotations were reconsidered so that there would not be an indefensible duplication of any topic in either outline.

The revised composite topical outlines were then submitted to a group of five experienced teachers of general science enrolled in a Seminar in Science Education at Boston University in 1946-47. These teachers were asked to examine the outline critically to insure that the wording and the position of each topic in the outline was defensible, that there were no duplications of topics and that each topic in the outline was suitable for inclusion in general science at the eighth-grade level. No changes were made.

A further study was made of the individual topics contained in the approved outlines to determine whether they were stated in the textual material as topics or were implied in the context or in an illustration. This information was readily available from the white file cards.

Table III which follows shows the frequency of recurrence in the different textbooks analyzed of topics relating to Magnetism that were stated as topics in their respected textbooks, while Table IV shows the frequency of recurrence in the same textbooks of the same topics that were implied either in the context or in an illustration.

TABLE III

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO MAGNETISM USING ONLY TOPICS THAT ARE STATED AS TOPICS

Topics	Textbooks of General Science						Textbooks of General Science for the Eighth-grade Level										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
*Magnetism		*		*	*										*		4
Early ideas of magnetism		*			*												2
Theory of magnetism																	0
Magnets	*		*		*												3
Definition of a magnet						*	*										2
Kinds of magnets		*			*												2
Proprieties of magnets																	
Polarity							*										1
Magnetic attraction		*			*												2
Magnetic field		*	*		*	*											4
Lines of force																	0
Induced magnetism		*					*										2
Law of magnetic poles		*				*	*										3
Magnetic compass		*				*	*								*		4
The earth as a magnet		*			*		*										3
The dipping needle																	0
Relation of magnetism to electricity															*		1
Total	1	9	2	1	7	4	6	0	0	0	0	0	0	0	3	0	33

*Table III is read thus: The topic Magnetism is found stated as a topic in Books B, D, E and O, a total of four different textbooks.

TABLE III

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO MAGNETISM
USING ONLY TOPICS THAT ARE STATED AS TOPICS

Topics	Textbooks of General Science											Textbooks of General Science for the Eighth-grade Level										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
*Magnetism		*		*	*										*		4
Early ideas of magnetism		*			*												2
Theory of magnetism																	0
Magnets	*		*		*												3
Definition of a magnet						*	*										2
Kinds of magnets		*			*												2
Properties of magnets																	
Polarity							*										1
Magnetic attraction		*			*												2
Magnetic field		*	*		*	*											4
Lines of force																	0
Induced magnetism		*					*										2
Law of magnetic poles		*				*	*										3
Magnetic compass		*				*	*								*		3
The earth as a magnet		*			*		*										3
The dipping needle																	0
Relation of magnetism to electricity															*		1
Total	1	9	2	1	7	4	6	0	0	0	0	0	0	0	3	0	33

*Table III is read thus: The topic Magnetism is found stated as a topic in Books B, D, E and O, a total of four different textbooks.

TABLE IV

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO MAGNETISM USING ONLY TOPICS THAT ARE IMPLIED IN THE CONTEXT OR IN AN ILLUSTRATION

Topics	Textbooks of General Science						Textbooks of General Science for the Eighth-grade Level										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
*Magnetism	*		*			*	*		*	*	*	*		*			9
Early ideas of magnetism			*	*			*										3
Theory of magnetism		*		*		*											3
Magnets		*				*								*	*		4
Definition of a magnet		*		*								*		*			4
Kinds of magnets			*			*	*							*	*		5
Properties of magnets																	
Polarity	*	*	*	*		*						*		*	*		8
Magnetic attraction	*		*	*		*	*		*	*	*	*		*	*		11
Magnetic field	*			*										*	*		4
Lines of force	*		*		*										*		4
Induced magnetism				*		*								*	*		4
Law of magnetic poles	*		*	*	*					*	*	*		*	*		9
Magnetic compass	*		*	*	*				*	*	*	*					8
The earth as a magnet			*	*		*				*	*			*	*		7
The dipping needle		*		*		*											3
Relation of magnetism to electricity	*	*				*											3
Total	8	6	9	11	3	10	4	0	3	5	5	6	0	10	9	0	89

*Table IV is read thus: The topic Magnetism is implied either in the context or in an illustration in Books A, C, F, G, I, J, K, L, and N, a total of nine different textbooks.

TABLE IV

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS RELATED TO MONOPOLY USING ONLY TOPICS THAT ARE IMPLIED IN THE CONTEXT OR IN ILLUSTRATION

Topics	Textbooks of General Science					Textbooks of General Science Based for the Eighth Grade Level						Total
	A	B	C	D	E	F	G	H	I	J	K	
*Monopolies					*	*	*		*	*		5
Early types of monopolies												
Mercury	*		*	*								3
Mercantilism					*							1
Trusts												
Corporations					*							1
Monopolies of necessities						*	*					2
Public utilities												
Natural monopolies												
Patents												
Copyrights												
Trade-marks												
Franchises												
Trusts												
Combinations												
Pools												
Holding companies												
Interlocking directorates												
Mergers												
Consolidations												
Trusts												
Combinations												
Pools												
Holding companies												
Interlocking directorates												
Mergers												
Consolidations												
Trusts												
Combinations												
Pools												
Holding companies												
Interlocking directorates												
Mergers												
Consolidations												
Trusts												
Combinations												
Pools												
Holding companies												
Interlocking directorates												
Mergers												
Consolidations												
Total	3	1	2	1	3	2	1	0	1	1	0	15

*Table IV is based upon: The topic Monopolies is implied or in an illustration in Books A, C, E, I, and K, and a total of nine different textbooks.

Findings Tables III and IV. Tables III and IV show that in the textual materials analyzed subject-matter topics and sub-topics that were contained in the composite topical outline for the area Magnetism were stated as topics 33 times. The same topics and sub-topics were implied in the context or in an illustration in the same textual materials 89 times.

Table V which follows shows the frequency of recurrence in the different textbooks analyzed of subject-matter topics and sub-topics relating to Electricity that were stated as topics while Table VI shows the frequency of recurrence in the same textual materials of the same topics and sub-topics that were presented in an implied form.

TABLE V

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO ELECTRICITY USING ONLY TOPICS THAT ARE STATED AS TOPICS

Topics	Textbooks of General Science						Textbooks of General Science for the Eighth-grade Level										Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Electricity																	
*What is electricity?		*	*		*	*											4
Electrons	*	*	*	*	*	*	*				*						8
Electric currents					*	*											2
General methods of producing electricity																	0
Static or frictional electricity	*	*		*	*	*											5
Methods of producing																	
Conductors; insulators	*		*	*	*		*		*	*					*		8
Lightning	*	*	*	*	*		*	*			*				*		9
Electroscope				*													1
Galvanoscope	*	*															2
The Leyden jar	*			*													2
Condensers	*																1
Current electricity		*	*	*	*		*							*			6
Methods of producing current electricity																	
Chemical action																	0
Induction				*	*												2
The electric circuit		*	*	*	*		*		*	*		*			*		9
Units of measure of electricity	*	*	*	*	*					*	*			*	*		9

*Table V is read thus: The topic What is electricity? is found stated as a topic in Books B, C, E, and F, a total of four different textbooks.

V. TEXT

PERSONAL OR BUSINESS TRANSACTIONS IN DIFFERENT SCHOOLS AND SOCIETIES

SCHOOL OR DISTRICT MAY STATE THAT BOOKS ONLY TO BE USED

| Topics | Textbooks of General Reference | | | | | | Textbooks of Special Reference | | | | | |

TABLE V (Concluded)

Topics	Textbooks of General Science						Textbooks of Science for Eighth-grade Level										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
Electricity from chemical action		*				*								*			3
Electric cells																	
The simple galvanic cell		*		*	*							*					4
The dry cell	*	*	*	*	*												5
Series and parallel connections	*	*			*												3
Storage batteries	*	*	*	*	*	*											6
Electricity produced by induction: generators	*	*	*		*	*			*								6
Electromagnets	*	*	*	*	*	*	*		*	*		*		*	*		12
The electric bell	*	*	*	*	*	*	*								*		8
The telephone	*	*	*	*	*				*					*			7
The telegraph	*	*	*	*	*		*							*			7
The electric motor	*	*	*	*	*	*				*							7
The circuit breaker					*												1
Transmission and use of electricity																	
Transformers	*	*	*	*	*												5
Electric lighting	*	*	*	*	*										*		6
Electric heating	*	*	*	*	*	*				*		*			*		9
Electric appliances	*				*	*				*							4
Electroplating	*			*	*												3
Electrotyping	*		*	*	*	*											5
Safety and electricity																	
Fuses	*	*	*	*	*	*	*			*					*		9
Other precautions																	0
Total	23	23	20	24	28	14	9	1	5	8	3	4	0	6	9	0	178

TABLE 1 (Continued)

| Topics | Text encoding level (Hughes 1992) | | |

TABLE VI

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO ELECTRICITY USING ONLY TOPICS THAT ARE IMPLIED IN THE CONTEXT OR IN AN ILLUSTRATION

Topics	Textbooks of General Science						Textbooks of General Science for the Eighth-grade Level										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
Electricity																	
*What is electricity?										*							1
Electrons										*				*			2
Electric currents	*		*						*	*		*			*		6
General methods of producing electricity	*	*	*		*	*				*							6
Static or frictional electricity			*								*				*		3
Methods of producing		*	*		*										*		4
Conductors; insulators		*				*						*					3
Lightning						*											1
Electroscope																	0
Galvanoscope																	0
The Leyden jar							*										1
Condensers	*		*	*					*								4
Current electricity	*								*			*					3
Methods of producing current electricity	*	*	*	*	*	*						*			*		8
Chemical action			*											*	*		3
Induction	*	*				*						*			*		5
The electric circuit	*					*								*			3
Units of measure of electricity						*											1

*Table VI is read thus: The topic What is electricity? is implied either in the context or in an illustration in Book J.

TABLE VI

FREQUENCY OF RECURRENCE IN DIFFERENT TEXTBOOKS OF TOPICS AND SUB-TOPICS RELATED TO ELECTRICITY USING ONLY TOPICS THAT ARE IMPLIED IN AN ILLUSTRATION

| Topics | Textbooks of General Science | | |

TABLE VI (Concluded)

Topics	Textbooks of General Science							Textbooks of Science for Eighth-grade Level									Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Electricity from chemical action														*			1
Electric cells																	
The simple galvanic cell	*		*			*	*			*				*	*		7
The dry cell						*								*	*		3
Series and parallel connections						*									*		2
Storage batteries							*			*		*			*		4
Electricity produced by induction; generators																	0
Electromagnets																	0
The electric bell									*								1
The telephone						*											1
The telegraph						*			*								2
The electric motor							*								*		2
The circuit breaker																	0
Transmission and use of electricity																	
Transformers																	0
Electric lighting			*			*	*		*	*		*					6
Electric heating					*		*		*								3
Electric appliances			*	*								*			*		4
Electroplating																	0
Electrotyping																	0
Safety and electricity																	
Fuses						*			*								2
Other precautions		*	*	*					*						*		5
Total	8	6	11	4	4	14	6	0	9	7	1	8	0	6	13	0	97

TABLE VI (Concluded)

| Topics | Textbooks of General Interest | | |

Findings Tables V and VI. The facts presented in Tables V and VI show that in the textual materials analyzed subject-matter topics and sub-topics that were contained in the composite topical outline for the area Electricity were stated as topics 178 times. The same topics and sub-topics were implied in the context or in an illustration in the same textual material 97 times.

Table VII which follows presents a summary of the frequency of recurrence of the topics and sub-topics related to the areas Magnetism and Electricity in textbooks of general science for no designated grade and in textbooks of general science written specifically for grade eight.

TABLE VII

A SUMMARY OF THE FREQUENCY OF RECURRENCE OF THE TOPICS AND SUB-TOPICS RELATED TO MAGNETISM AND ELECTRICITY IN TEXTBOOKS OF GENERAL SCIENCE FOR NO DESIGNATED GRADE LEVEL AND FOR GRADE EIGHT

Topics	Number of Textbooks of General Science		
	No Designated Grade Level	Grade Eight Only	Total
MAGNETISM			
*Magnetism	6	7	13
Early ideas of magnetism	4	1	5
Theory of magnetism	3	0	3
Magnets	5	2	7
Definition of a magnet	3	3	6
Kinds of magnets	4	3	7
Properties of magnets			
Polarity	5	4	9
Magnetic attraction	6	7	13
Magnetic field	6	2	8
Lines of force	3	1	4
Induced magnetism	3	3	6
Law of magnetic poles	6	6	12
Magnetic compass	6	6	12
The earth as a magnet	5	5	10
The dipping needle	3	0	3
Relation of magnetism to electricity	3	1	4
Totals for Magnetism	71	51	122
ELECTRICITY			
Electricity			
What is electricity?	4	1	5
Electrons	6	4	10
Electric currents	4	4	8

*Table VII is read thus: The topic Magnetism is found in six textbooks of general science for no designated grade and in seven textbooks of general science for grade eight, a total of thirteen different textbooks.

TABLE VII

SUMMARY OF THE FREQUENCY OF REFERENCE TO THE TOPICS AND SUB-TOPICS RELATED TO MAGNETISM AND ELECTRICITY IN TEXTBOOKS OF GENERAL SCIENCE FOR NO DESIGNATED GRADE LEVEL AND FOR GRADE EIGHT

Topics	Number of Textbooks of General Science		
	No Designated Grade Level	Grade Eight Only	Total
MAGNETISM			
*Magnetism	6	7	13
Early ideas of magnetism	4	1	5
Theory of magnetism	3	0	3
Magnets	5	2	7
Definition of a magnet	3	2	5
Kinds of magnets	4	3	7
Properties of magnets			
Polarity	5	4	9
Magnetic attraction	6	7	13
Magnetic field	6	2	8
Lines of force	3	1	4
Induced magnetism	3	2	5
Law of magnetic poles	4	8	12
Magnetic compass	6	6	12
The earth as a magnet	5	5	10
The dipping needle	3	0	3
Relation of magnetism to			
Electricity	3	1	4
Totals for Magnetism	71	51	122
ELECTRICITY			
Electricity			
What is electricity?	4	1	5
Electrons	6	4	10
Electric currents	4	4	8

*Table VII is read thus: The topic Magnetism is found in six textbooks of general science for no designated grade and in seven textbooks of general science for grade eight, a total of thirteen different textbooks.

TABLE VII (Concluded)

Topics	No Designated Grade Level	Grade Eight Only	Total
General methods of produc- electricity	5	1	6
Static or frictional elec- tricity	6	2	8
Methods of producing	3	1	4
Conductors; insulators	6	5	11
Lightning	6	4	10
Electroscope	1	0	1
Galvanoscope	2	0	2
The Leyden jar	2	1	3
Condensers	4	1	5
Current electricity	5	4	9
Methods of producing	6	2	8
Chemical action	1	2	3
Induction	5	2	7
The electric circuit	6	6	12
Units of measures of elec- tricity	6	4	10
Electricity from chemical action	2	2	4
Electric cells			
The simple galvanic cell	6	5	11
The dry cell	6	2	8
Series and parallel con- nections	4	1	5
Storage batteries	6	4	10
Electricity produced by in- duction: generators	5	1	6
Electromagnets	6	6	12
The electric bell	6	3	9
The telephone	6	2	8
The telegraph	6	3	9
The electric motor	6	3	9
The circuit breaker	1	0	1
Transmission and use of elec- tricity			
Transformers	5	0	5
Electric lighting	7	5	12
Electric heating	7	5	12
Electric appliances	5	3	8
Electroplating	3	0	3
Electrotyping	5	0	5
Safety and electricity			
Fuses	7	4	11
Other precautions	3	2	5
Totals for Electricity	180	95	275
Totals for Magnetism and Electricity	251	146	397

TABLE VII (Concluded)

Topics	No Desiderata Stated	Grade Eight Only	Total
General methods of production: electricity	5	1	6
Static or frictional electricity	6	2	8
Methods of producing	3	1	4
Conductors; insulators	8	5	13
Lighting	6	4	10
Electroscope	1	0	1
Galvanoscope	2	0	2
The Leyden jar	2	1	3
Condensers	4	1	5
Current electricity	5	4	9
Methods of producing	6	2	8
Chemical action	1	2	3
Induction	5	2	7
The electric circuit	6	6	12
Units of measures of electricity	6	4	10
Electricity from chemical action	2	2	4
Electric cells			
The simple galvanic cell	6	5	11
The dry cell	6	2	8
Series and parallel connections	4	1	5
Storage batteries	6	4	10
Electricity produced by induction: dynamo generators	5	1	6
Electromagnets	6	6	12
The electric bell	6	3	9
The telephone	6	3	9
The telegraph	6	3	9
The electric motor	6	3	9
The circuit breaker	1	0	1
Transmission and use of electricity			
Transformers	5	0	5
Electric lighting	7	5	12
Electric heating	7	5	12
Electric appliances	6	3	8
Electroplating	3	0	3
Electrotyping	5	0	5
Safety and electricity			
Fuses	7	4	11
Other precautions	3	2	5
Totals for Electricity	180	95	275
Totals for Magnetism and Electricity	251	146	397

Findings Table VII. A comparison of six textbooks of general science suitable for use at the junior-high-school level but not written for a designated grade level with ten general science textbooks written specifically for the eighth-grade level shows the following summaries, respectively: total recurrences of topics in the area Magnetism, 71 in contrast to 51; total recurrences of topics in the area Electricity, 180 in contrast to 95; total recurrences of topics in both the area Magnetism and the area Electricity, 251 in contrast to 146. The topics for Magnetism recurred a total of 122 times, the topics for Electricity recurred a total of 275 times, and the topics for both Magnetism and Electricity recurred a total of 397 times.

Finding Table VII. A comparison of six textbooks of general science suitable for use at the junior-high-school level but not written for a designated grade level with ten general science textbooks written specifically for the eighth-grade level above the following summaries, respectively: total recurrences of topics in the area Magnetism, 71 in contrast to 91; total recurrences of topics in the area Electricity, 130 in contrast to 95; total recurrences of topics in both the area Magnetism and the area Electricity, 201 in contrast to 186. The topics for Magnetism recurred a total of 122 times, the topics for Electricity recurred a total of 275 times, and the topics for both Magnetism and Electricity recurred a total of 397 times.

CHAPTER IV

THE RESEARCH: PART III

STATEMENT OF THE PROBLEM

The purpose of this phase of the investigation is the determination in the areas Magnetism and Electricity of the experiments found in the selected textual materials that are related to the topics in the composite topical outlines, the utilization of such data in the preparation of composite experiments, the assignment of said composite experiments to designated scientific principles, and the validation and evaluation of these principles.

ANALYSIS OF TEXTBOOKS AND LABORATORY MANUALS FOR EXPERIMENTS FROM THE AREAS MAGNETISM AND ELECTRICITY

The fourth examination of the textual materials was made in order to determine the experiments relating to Magnetism and the experiments relating to Electricity that were contained therein. In this examination as in the previous one all the selected manuals and workbooks were included but special scrutinization was given to the laboratory manuals. The composite topical outlines and the white cards on which subject-matter topics had been recorded were also used. Each piece of the textual material was carefully read sentence by sentence in order to ascertain the experiments described therein.

The examination of the workbooks and laboratory manuals was comparatively simple as experiments described in them were generally assigned definite titles or headings, although there was a wide variety of such headings. Six authors used the word Experiment, three used Problem, two used Demonstration, two used Exercise, one used Activity, one used Experience and one used a question. For the purposes of this investigation, however, most of these headings were considered to have essentially the same connotation, and the word Experiment was selected as a common designation.

As each experiment relating to Magnetism or to Electricity was located it was copied in its entirety on paper, 9" x 12". The title of the experiment, expressed in interrogative form, and the source reference were copied on a pink file card similar to the white card used for topic data. The code letter of the text where the experiment was described was written in the upper right corner of the card. These pink cards were then filed with the appropriate white cards. If there were any topics that did not have related experiments a re-examination of the textual material was made to ascertain that no such experiment had been overlooked.

The next step in the investigation was the formulation of the composite experiment. Many of the experiments found in the texts were similar. The best features of these similar experiments were incorporated in the composite experiment, the criterion used in such selection being the quality

of the available material. Any good idea was freely "borrowed" because the investigator was in complete accord with the statement made by Franklin B. Carroll[1] who said, "There is no such word as plagiarism in the classroom teacher's lexicon." The following form was adhered to in the composing of the experiments:

Title (in an interrogatory form.)
Materials
Procedure
Conclusion

By this procedure, a sufficiently wide latitude in choice of experiments was provided to accommodate the individual needs of any particular eighth grade as well as the varying capabilities of different eighth grades and to make allowances for possible differences in time allotments given to the topics Magnetism and Electricity. After all the composite experiments had been formulated their titles were copied on the other side of the pink file cards. These were then copied beside the appropriate topic on the composite topical outline.

ANALYSIS OF TEXTBOOKS AND LABORATORY MANUALS FOR PRINCIPLES OF SCIENCE RELATED TO THE TOPIC MAGNETISM AND ELECTRICITY

The fifth examination of the textual material was made for the purpose of determining the principles relating to the topics Magnetism and Electricity that were included therein.

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[1] Franklin B. Carroll, Understanding Our World, p. viii, The John C. Winston Company, Philadelphia: 1943.

of the available material. Any good idea was freely "borrowed" because the investigator was in complete accord with the statement made by Franklin B. Carroll[1] who said, "There is no such word as plagiarism in the classroom teacher's lexicon." The following form was adhered to in the composing of the experiments:

Title (in an interrogatory form.)
Materials
Procedure
Conclusion

By this procedure, a sufficiently wide latitude in choice of experiments was provided to accommodate the individual needs of any particular eighth grade as well as the varying capabilities of different eighth grades and to make allowances for possible differences in time allotments given to the topics Magnetism and Electricity. After all the composite experiments had been formulated their titles were copied on the other side of the pink file cards. These were then copied beside the appropriate topic on the composite topical outline.

ANALYSIS OF TEXTBOOKS AND LABORATORY MANUALS FOR PRINCIPLES OF SCIENCE RELATED TO THE TOPIC MAGNETISM AND ELECTRICITY

The fifth examination of the textual material was made for the purpose of determining the principles relating to the topics Magnetism and Electricity that were included therein.

---

[1] Franklin B. Carroll, Understanding Our World, p. viii. The John C. Winston Company, Philadelphia: 1942.

The criteria for principles of science used in the important research studies made by Robertson, Wise, Martin, Fleish and Jones were again reviewed. The composite topical outlines, the set of white file cards containing topics and the set of pink file cards containing titles of composite experiments were also used in this part of the research.

Before beginning the examination of the textual material for the determination of principles relating to Magnetism and Electricity it was necessary to accept a list of criteria for these principles.

Of all the lists of criteria studied in the survey of related literature and later reviewed, the list used by Jones and the one used by Reek seemed more applicable to this investigation. Both of these lists were basically in accord and both omitted the criterion "must not be a part of a larger principle," — an omission that was justified also in this investigation because such a criterion is not only highly impractical at the eighth-grade level but would militate against the successful determination of principles as at present stated in eighth-grade textbooks of science. This specific problem was also considered in the 1946-47 Seminar in Science Education at Boston University and after much discussion the members of the Seminar agreed to accept a statement as a principle:

> If, though it does not state all of the elements of the principle, it is referred to (or implied) by the author or authors as being part of the said principle.

The following list of criteria is a composite of the list used by Jones, the one used by Reek and the exception

adopted by the Seminar. For the purpose of this investigation a principle of science is defined as a comprehensive generalization which

1. Is stated definitely, not inferred
2. Is true with but rare exceptions within limitations set by the statement
3. Is a clear statement of a process or of an interaction
4. Is meaningful outside the context
5. Is not merely a definition or a description
6. Does not deal with specific substances or varieties
7. Is demonstrable experimentally
8. Though it does not state all of the elements of the principle, is referred to (or implied) by the author as being part of the said principle.

The section of each textbook the portion related to Magnetism and Electricity was again carefully read sentence by sentence for any generalized statement which might satisfy the criteria set up to govern the selection of a principle of science. All portions of the context which were intended to be read or studied by pupils were included in this analysis.

The results of this analysis were very disappointing. Principles as such received either little or no attention in the textual material that was analyzed. In seven of the textbooks examined there were lists of key statements or summaries some of which implied vaguely a minor scientific principle for the topics Magnetism and Electricity. In two books, Book E and Book J, the authors stated four and five science principles, respectively.

The lists of scientific principles formulated by Wise and Jones were then carefully examined for principles especially applicable to the area Magnetism and Electricity.

Each composite experiment and related topic was then assigned to one or more of these designated principles if it seemed to the investigator that the discussion of the topic and the performance of the experiment would lead to an increased understanding of such principle or principles.

VALIDATION AND EVALUATION OF TOPICS AND EXPERIMENTS IN MAGNETISM AND ELECTRICITY FOR THE DEVELOPMENT OF DESIGNATED PRINCIPLES

After the investigator had assigned topics and experiments to designated principles to which they were closely related the specialist in the teaching of science directing this investigation then critically examined these assignments to insure their proper assignment to principles. Thus the assignment of topics and experiments to principles they represented was properly validated.

The list of topics and experiments together with the principles they represented were then presented to five experienced teachers of general science, all members of a Seminar in Science Education, Boston University, 1946-47, who were asked to make separate evaluations of the topics and experiments.

Each evaluator was instructed to mark separately a 5, 4, 3, 2 or 1 in the blank space provided for each topic and for each experiment that had been assigned to a designated principle to indicate his judgment on the following basis:

5 The topic* (or the experiment*) being evaluated is ideally suited

*A discussion of the topic and the performance of the experiment is here implied. Topics and experiments are considered separately when evaluated.

4 Well suited
3 Neither well nor poorly suited
2 Poorly suited
1 Not at all suited
for helping to develop in general science at the eighth-grade level an understanding of the principle for which the topic (or the experiment) is marked.

The evaluators in the Seminar working independently marked only those topics for which there were related experiments. After this fact was discovered a different group of five evaluators, all experienced teachers of general science at the eighth-grade level, was then called upon in an emergency created by a time factor to do further evaluation.

The second group of five evaluators working independently, using the same directions that were used by the original evaluators, was instructed to mark all topics and sub-topics in the master topical outline which were not marked by the original evaluators. The latter five evaluators were also instructed to indicate for each experiment whether that experiment is more appropriately done at the eighth-grade level as a laboratory experiment (L) or as a demonstration (D), or is equally appropriate (X) for performance either as a laboratory experiment or as a demonstration.

The combined judgments of the ten evaluators is presented in Table VIII which shows the relative values at the eighth-grade level of topics and experiments in Magnetism and Electricity for the development of designated principles. Some of the scientific principles in this table may not be stated in language appropriate for the eighth-grade level for

the principles are primarily for the guidance of the teacher who will of necessity present such principles in the vocabulary suitable for a particular group. Some principles, of course, could be presented exactly as stated in the table. Comprehensive principles by Wise may be repeated in part for the same assignment by less comprehensive principles by Jones. Such repetition is intended to make the principle of greater value to teachers who may use the results of this investigation.

Table VIII, which follows, shows the relative values at the eighth-grade level of topics and experiments in magnetism and electricity for the development of designated principles. The table further indicates for each experiment whether at the eighth-grade level the experiment is, in the opinion of three or more of the five evaluators, more appropriately done as a laboratory experiment (L) than as a demonstration (D), or <u>vice versa</u>, or is equally appropriate for performance as a laboratory experiment or as a demonstration.

TABLE VIII

RELATIVE VALUES AT THE EIGHTH-GRADE LEVEL OF TOPICS AND EXPERIMENTS IN MAGNETISM AND ELECTRICITY FOR THE DEVELOPMENT OF DESIGNATED PRINCIPLES

Topics	Value	Experiments	LDX	Value	Principles
*Magnetism **Early ideas of magnetism	25				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	20				When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)
	14				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (54)

*One or more asterisks indicate that the topic appeared in five or more of the ten textbooks of general science written specifically for grade eight.

**Table VIII is read thus: A discussion of the topic "Early ideas of magnetism" is considered to contribute to a development of an understanding of the principles "Pieces of iron . . . field," (Wise's principle 102), "When a magnet . . . south," (Jones' principle 5) and "Like magnetic poles . . . each other" (Wise's principle 54). No related experiment suitable for grade eight was found.

The topic was valued at 25 by the five evaluators who judged the topics and experiments separately using a scale 1-5 to indicate the degree of suitability of the development at the eighth-grade level of an understanding of the principle "Pieces of iron . . . field."

The L or D in the LDX column indicates whether the experiment is more appropriately done as a laboratory experiment (L) or as a demonstration (D). X indicates equal appropriateness for either method, L or D.

TABLE VIII

THE DEVELOPMENT OF DESIRABLE RELATIVE VALUES AT THE SOUTHWESTERN MACHINERY COMPANY

Topics	Values	Judgments	IDX	Values
"Negative" topics of immediate importance	28			
	50			
	14			
Topics of long-range importance				

*None of these statistics appeared in the text of the report.

Because of the urgency of the situation, Mr. Bradley decided to call a meeting of the executive committee to discuss the problem. The meeting was held on March 15, 19--, and was attended by Mr. Bradley, Mr. Wilson, Mr. Thompson, and Mr. Jones. Mr. Bradley opened the meeting by stating that he had called it to discuss the problem of the declining sales of the Model 500 machine. He said that he had received reports from the sales force that the machine was not selling as well as it had in the past, and that he was concerned about the situation. He asked the committee members to give their opinions on the matter.

Mr. Wilson said that he thought the problem was due to the fact that the machine was not as reliable as it had been in the past. He said that he had received a number of complaints from customers about the machine breaking down frequently. He suggested that the company should spend more money on research and development to improve the reliability of the machine.

Mr. Thompson disagreed with Mr. Wilson. He said that he thought the problem was not with the machine itself, but with the way it was being marketed. He said that he had received reports from the sales force that the machine was not being demonstrated properly to potential customers. He suggested that the company should spend more money on training the sales force to demonstrate the machine properly.

Mr. Jones said that he thought both Mr. Wilson and Mr. Thompson had valid points. He said that he thought the company should spend more money on both research and development and on training the sales force. He suggested that the company should also spend more money on advertising to create a better image for the machine.

Mr. Bradley said that he thought all of the suggestions were good ones. He said that he would like to see the company spend more money on research and development, on training the sales force, and on advertising. He asked the committee members to prepare a report on their recommendations and to present it to the board of directors at the next meeting.

The meeting was adjourned at 4:30 P.M.

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Theory of magnetism	25				Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W219)
	24				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	22				Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	19				A magnet always has at least two poles and is surrounded by a field of force. (W159)
Magnets Definition of a magnet	25				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	18				Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	19				Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	13				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)

TABLE VIII (Continued)

Topics	Values	Experiments	Tbx	Values	Principles
Theory of magnet-ism Magnets Definition of a magnet A magnet always has at least two poles and is surrounded by a field of force. (M1B9) A magnet always has at least two poles and is characterized by a field of force. (M1B9) Magnetic energy, or magnetism, extends in all directions from a magnet through space A magnet is surrounded by a magnetic field. (M1F1) Magnetic lines of force, steel, cobalt, or nickel may be magnetized by induction when placed within the magnetic field. (M1F3) Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (M2A)	2S 3S 4S 5S 6S 7S 8S	Magnets demonstrate the existence of magnetic lines of force. (M1F3) Place a magnet under a piece of cardboard or glass and sprinkle iron filings on it. (M1F4) Bring a magnet always has at least two poles and is surrounded by a field of force. (M1B9) Bring a magnet always has at least two poles and is surrounded by a field of force. (M1B9) Place a magnet under a piece of cardboard or glass and sprinkle iron filings on it. (M1F4) Bring a magnet always has at least two poles and is surrounded by a field of force. (M1B9) Place a magnet under a piece of cardboard or glass and sprinkle iron filings on it. (M1F4)			

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Kinds of magnets	25				When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)
	22				Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	16				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	12				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	14				Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
Properties of magnets					
Polarity	25	What happens to a magnet when it is suspended by a string? (Appendix A, Experiment I)	L	20	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	25			25	When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)

TABLE VIII (Continued)

Topics	Value	Explanations	Value
Kinds of magnets	25	When a magnet is allowed to float or swing free-ly, it will turn until its points north and south. (DC)	
	22	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (MISC)	
	18	A magnet always has at least two poles and is surrounded by a field of force. (MISC)	
	15	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (MEW)	
	14	If we assume external magnetic lines of force, we can explain all magnetic actions from a north pole to a south pole. (JJ)	
Properties of magnets	25	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (MEW)	20
	23	Exactly what is meant by saying that a magnet has polarity? (AJK)	

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	25			25	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	16			7	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
*Magnetic Attraction	24	What substances will a magnet attract? (Appendix A, Experiment II)	L	25	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	16			9	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
	20			13	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	23			11	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	18			16	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	18			16	Any magnet sets up lines of force about the poles of the magnet. (J3)

TABLE VIII (Continued)

Topics	Experiments	Link	Value
	Principles		
	A magnet always has at least two poles and is surrounded by a field of force. (MISD)		25
	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (MSD)		7
	places of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (MFOD)	IL	25
	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (MSD)		9
	A magnet always has at least two poles and is surrounded by a field of force. (MFSD)		15
	Like magnetic poles always repel each other while unlike poles always attract each other. (MSA)		11
	Magnetic energy, or magnetism, exists in all directions from a magnet through the space surrounding it. (M)		18
	Any magnet has its strongest force at its poles. (MSD)		15

*Magnetic Attraction

	Experiments		
	What substances will a magnet attract? (Apparatus A, Experiment II)	IL	24
			15
			20
			23
			18
			18

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Values	Principles
	6	What parts of a magnet have the greatest pulling power or magnetic force of attraction? (Appendix A, Experiment III)	L	19	A magnet always has at least two poles and is surrounded by a field of force. (W159)
				20	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
				11	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
				17	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
				16	Any magnet sets up lines of force about the poles of the magnet. (J3)
				11	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	20	Can the magnetism be removed from a magnet by heating it or by jarring it? (Appendix A, Experiment IV)	D	24	Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W219)
				21	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)

TABLE VIII (Continued)

Topics	Value	Experiments	Max	Values	Principles
		What parts of a magnet have the greatest pulling power or magnetic force of attraction? (Appendix A, Experiment IV)	L	19	A magnet always has at least two poles and is surrounded by a field of force. (W58)
				20	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	6	Experiment III)		11	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W58)
				IV	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W106)
				16	Any magnet sets up lines of force about the poles of the magnet. (J3)
				11	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	20	Can the magnetism be removed from a magnet by heating it or by jarring it? (Appendix A, Experiment IV)	D	24	Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W319)
				21	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
				12	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
				9	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
				12	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
				15	A magnet always has at least two poles and is surrounded by a field of force. (W159)
Magnetic field	25	What is the nature of the magnetic field of force that surrounds a magnet? (Appendix A, Experiment V)	D	24	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	25			25	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	23			20	Any magnet sets up lines of force about the poles of the magnet. (J3)
	13			12	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	22			18	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	18			16	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
Lines of force	25	How can a permanent record of a magnetic field showing the "lines of force" be made? (Appendix A, Experiment VI)	D	24	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	23			21	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	24			24	Any magnet sets up lines of force about the poles of the magnet. (J3)
	12			10	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
	22			14	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	14			16	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)

TABLE XLIII (Continued)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Induced magnetism	25	How can a magnet be made by induction? (Appendix A, Experiment VII)	L	25	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field? (W102)
	17			19	Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W219)
	18			21	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	20			21	Any magnet sets up lines of force about the poles of the magnet. (J3)
	15			9	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
	19			19	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	15			17	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)

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TABLE VIII (Continued)

Topics	Verbs	Nouns	Prepositions
Tuning messages	Send	Message	To
	Receive	Message	From
	Broadcast	Message	To
	Receive	Message	From
	Send	Message	To
	Receive	Message	From
	Send	Message	To
	Receive	Message	From
	Send

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
*Law of magnetic poles	25	What happens when the same kinds and different kinds of poles of two magnets, one of which is free to move, are brought near each other? (Appendix A, Experiment VIII)	X	25	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	20			18	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	15			14	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
	19			19	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
*Magnetic compass	25	How can a magnetic compass be made? (Appendix A, Experiment IX)	L	25	When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)
	25			18	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	22			20	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	13			14	Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W219)

TABLE XVIII (Continued)

Topics	Values	Excitements	Values	Partners
Draw to straight	25	Meet Indians when you take the train to Albuquerque	X	25
	20	Two of which is a beautiful girl		20
	15	Ride camels to Agadir, and there meet Indians (Appendix A, Experiment VIII)		15
	10	Ride camels to Agadir, and there meet Indians (Appendix A, Experiment IX)		10
Straights to commerce	25	Work on a merchant ship	I	25
	20	Become a merchant in Agadir (Appendix A, Experiment X)		20
	15	Become a merchant in Agadir (Appendix A, Experiment IX)		15
	10	Become a merchant in Agadir (Appendix A, Experiment VIII)		10

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	14			17	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	11			10	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
	18			20	Any magnet sets up lines of force about the poles of the magnet. (J3)
	17			17	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
*The Earth as a magnet	25				When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)
	25				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	23				Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)

TABLE VIII (Continued)

Subject	Value	Phenomenon	TDX	Value	Predicate
	78			74	Either [illegible], cost, [illegible], or difficulty may [illegible]
					[illegible] message [illegible] [illegible] motivation when [illegible] with-
					in a message [illegible]. (MISC)
	71			10	The [illegible] of artificial [illegible] to [illegible] [illegible]
					[illegible] [illegible] [illegible] [illegible] [illegible]

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	24				Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	20				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	9				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
The dipping needle	25	How can the action of the dipping needle be illustrated? (Appendix A, Experiment X)	D	24	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	25			20	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	22			22	When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J5)
	19			20	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	17			10	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)

TABLE XIII (Continued)

Topics	Values	Expressions	DUX	Values	Examples
Prepositions					
Please note, also, that, or if you may use [illegible] with [illegible]					
(SCW)					
in a message to [illegible]					
(MSG)					
A message always has at least two parts and					
(MSG)					
[illegible] to start a [illegible]					
(MSG)					
Type correction to [illegible] between					
the [illegible] and [illegible] as the					
two messages.					
(MSG)					
A message always has at least two parts and					
(MSG)					
[illegible] to start a [illegible]					
(MSG)					
Type correction to [illegible] between					
the [illegible] and [illegible] as the					
two messages.					
(MSG)					
Type message [illegible] before [illegible] and					
[illegible] [illegible] [illegible]					
(MSG)					
Type message [illegible] before [illegible] and					
[illegible] [illegible] [illegible]					
(MSG)					
Type [illegible]

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	11			6	Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W219)
	9			8	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
Relation of magnetism to electricity	24	How does an electric current flowing through a horizontal wire affect a	L	20	An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W11)
	21	compass needle under or above and parallel to the wire? (Appendix A, Experiment XI)		21	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W102)
Electricity What is electricity?	25				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)

TABLE VIII (Continued)

Topics	Value	Experiments	LUX	Value	Principles
Relation of magnetism to electricity	24	How does an electric current flowing through a horizontal wire affect a compass needle under or above and parallel to the wire? (Appendix A, Experiment XI)	L	20	An electrical charge in motion produces a magnetic field about the conductor, the direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (WII)
	23			21	Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (WIOC)
Electricity					
What is electricity?	25				Electric currents may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (WEV)
					Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (WE19)
	9			8	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (WE5)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	12				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)
	13				An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	23				Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
	14				All electric cells change chemical energy into electrical energy. (J2)
Electrons	14				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)
	25				Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
	25				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)

TABLE VIII (continued)

Antonym	Letter	Example	OBX	Letter	Antonym

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	14				All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
Electric currents	25				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	13				An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	23				All electric cells change chemical energy into electrical energy. (J2)
General methods of producing electricity	25				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	14				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)

Topics	Value	Experiments	[illegible]	Value	Principles
Electric cantata	1.				All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W83)
	2.				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W87)
	13				An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W86)
	23				All electric cells change chemical energy into electrical energy. (L2)
General methods of producing electricity	25				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W87)
	14				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	24				All electric cells change chemical energy into electrical energy. (J2)
	12				An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
Static or frictional electricity Methods of producing	25	Can electric sparks be produced by shuffling the feet on a carpet and then touching something? (Appendix A, Experiment XII)	L	25	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	18			18	In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)
	23			21	Like electrical charges repel and unlike electrical charges attract. (W23)
		How can static or frictional electricity be produced? (Appendix A, Experiment XIII)	L	25	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
				16	In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)

TABLE XIII (Continued)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
				18	Like electrical charges repel and unlike electrical charges attract. (W23)
		How do different kinds of electrical charges act toward one another? (Appendix A, Experiment XIV)	X	25	Like electrical charges repel and unlike electrical charges attract. (W23)
				20	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
				14	In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)
*Conductors and Insulators	15	How can substances be tested to see if they are conductors	L	14	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	16	or non-conductors (insulators) of electricity? (Appendix A, Experiment XV)		12	An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	24			23	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)

TABLE VIII (Continued)

Topics	Values	Explanations	INDX	Value
Interactions and Consequences*	15	How can sub-assemblies be tested to see if they are compatible? (XV)		
	25	Expectations (XV)		
	35	Electrical charges attract. (MS2)		18
		Like electrical charges repel and unlike electrical charges attract. (MS2)	X	25
		An electric current may be produced in three ways: by friction, by chemical action and by the use of a magnetic field. (MS7)		50
		In an energized body there are as many protons as electrons and the charges neutralize each other. A negative charge is an electron and a positive charge is a proton. (MS4)		14
		An electric current may be produced by chemical action by the use of a magnetic field. (MS7)		45
		Like electrical charges repel and unlike electrical charges attract. (MS2)		18

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	15			13	All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
Lightning	24				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	16				Whenever electric currents flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (J9)
	23				Like electrical charges repel and unlike electrical charges attract. (W23)
	20				Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points. (W37)
Electroscope	23				Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge. (W48)
	20				Like electrical charges repel and unlike electrical charges attract. (W23)
	21				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	18			18	All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
Lightning	24				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	16				Whenever electric currents flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (J9)
	23				Like electrical charges repel and unlike electrical charges attract. (W23)
	20				Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points. (W37)
Electroscope	23				Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge. (W48)
	20				Like electrical charges repel and unlike electrical charges attract. (W23)
	21				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Galvanoscope	20				Any magnet sets up lines of force about the poles of the magnet. (J3)
	18				Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	22				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
The Leyden jar	14				Condenser capacitance varies directly with the area of the plates, and inversely as the thickness of the insulation between them. (W169)
	20				Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge. (W48)
	20				Like electrical charges repel and unlike electrical charges attract. (W23)
	12				Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points. (W37)
	20				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)

Adjective	Value	Experiments	Value	Value
Any magnet acts upon iron or some other poles of the magnet. (SG)				
Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (TL)				
Like magnetic poles always repel each other and unlike poles always attract. (WSA)				
Conductors capable of carrying the same current parallel and in the same direction attract each other. (MSO)				
Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge. (WSA)				
Like electrical charges attract and unlike electrical charges repel each other. (WSC)				
Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points. (WSV)				
In an uncharged body there are as many positive as negative charges. The electrification by friction consists in the separation of these charges and the communication of one kind to the body rubbed. (WSO)				

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Condensers	14				Condenser capacitance varies directly with the area of the plates, and inversely as the thickness of the insulation between them. (W169)
	20				Like electrical charges repel and unlike electrical charges attract. (W23)
	20				Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge. (W48)
	12				Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points. (W37)
	20				In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W90)
*The electric circuit	23	What is an electric circuit? (Appendix A, Experiment XVI)	L	21	An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	19			20	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	23			23	All electric cells change chemical energy into electrical energy. (J2)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Units of measure of electricity	16				Electrical power is directly proportional to the product of the potential difference and the current. (W79)
	12				The electrical current flowing in a conductor is directly proportional to the potential difference and inversely proportional to the resistance.(W41)
Electricity from chemical action					
Electric cells					
*The simple galvanic cell	24	Can a simple cell consisting of two different metals separated by an	D	23	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	23	acid solution produce an electric current? (Appendix A, Experiment XVII)		25	An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	24			22	All electric cells change chemical energy into electrical energy. (J2)
The dry cell	24	How is a dry cell constructed and what seems to have happened in-	D	22	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	20	side a dry cell when it produced electricity? (Appendix A, Experiment XVIII)		19	An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more

(Continued)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
					active metal being charged negatively. (W18)
	24			25	All electric cells change chemical energy into electrical energy. (J2)
Series and parallel connections	9	How are dry cells connected in series and in parallel? Is more, or less current available at any one time when dry cells are connected in series instead of in parallel? (Appendix A, Experiment XIX)	D	7	In a series circuit the current is the same in all parts, the resistance of the whole is the sum of the resistance of the parts, and the voltage loss of the whole is the sum of the voltage losses of the parts. (W139)
	7			6	In a parallel circuit the total current is the sum of the separate currents, the voltage loss is the same for each branch, and the total resistance is less than the resistance of any one branch. (W140)
Storage batteries	23				An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	12				An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W18)
	19				All electric cells change chemical energy into electrical energy. (J2)

TABLE VIII (Continued)

Topics	Value	Experiments	XXX	Value
Series and parallel connections	8	How are dry cells connected in series and parallel? Experiment XIX)	D	
	7	Is a perfect electric circuit possible? (Page 84)	C	
	25	Electrical energy. (Page 85)		
	25	Electrical energy changed into active material by the current. (Page 86)		
	15	Primary batteries. (Page 87)		
	10	Storage batteries. (Page 88)		

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
Electricity produced by induction Generators	24	How can a magnet and a coil of wire be used to make (generate) an electric current? (Appendix A, Experiment XX)	D	23	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	10			17	An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (W35)
	15			12	The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil. (W72)
	23			22	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	18			16	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	5			5	An electric charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W11)
*Electromagnets	25	How can an electromagnet be made? Be made stronger? (Appendix A, Exp. XXI)	L	24	Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)

TABLE VIII (Continued)

Topics	Value	Experiments	LBX	Value	Principles
Electricity produced by induction: Generators	24	How can a magnet and a coil of wire be used to make (generate)	D	23	An electric current may be produced in three ways: by rubbing or friction, by chemical action and by the use of a magnetic field. (W47)
	10	an electric current (Appendix A, Experiment XX)		17	An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (W3C)
	16			12	The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil. (W72)
	23			22	A magnet always has at least two poles and is surrounded by a field of force. (W139)
	18			16	Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J1)
	5			5	An electric charge in motion produces a magnetic field about the conductor, the direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W11)
*Electromagnets	25	How can an electromagnet be made? Be made stronger? Appendix A, Exp. XX1)	I	24	Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W108)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	23			18	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	20			19	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	12			10	A force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
The electric bell	13	What makes an electric bell ring? (Appendix A,	X	16	Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W17)
	5	Experiment XXII)		6	An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W11)
	18			21	Any magnet sets up lines of force about the poles of the magnet. (J3)
	21			21	Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	19			20	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	25			18	A magnet always has at least two poles and is surrounded by a field of force. (WI89)
	20			19	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (WS4)
	12			10	A force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (WS5)
The electric bell	13	What makes an electric bell ring? (Appendix A, Experiment XXII)	X	16	Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (WI7).
	5			6	An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (WI1)
	19			21	Any magnet sets up lines of force about the poles of the magnet. (WS)
	21			21	Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (WI02)
	19			20	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (WS1)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
The telephone	23				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	15				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	19				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	7				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
The telegraph	23				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)
	17				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	19				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	6				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
The telephone	23				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W103)
	15				A magnet always has at least two poles and is surrounded by a field of force. (W139)
	13				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W84)
	7				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
The telegraph	23				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W103)
	17				A magnet always has at least two poles and is surrounded by a field of force. (W139)
	13				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W84)
	5				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
The electric motor	19	What is the principle of the electric motor? (Appendix A, Experiment XXIII)	D	19	Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W17)
	20			17	When a current-carrying wire is placed in a magnetic field there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the magnetic poles, providing that the wire is not parallel to the field. (W94)
	17			19	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
	14			15	A magnet always has at least two poles and is surrounded by a field of force. (W159)
	24			24	Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	7			11	The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
The circuit breaker	21				Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W102)

TABLE VIII (Continued)

Topics	Value	Explanations	Index	Value	Explanations
The electric motor - for electric motor	7B	What is the principle of the electric motor? (Appendix X III)	D	7B	Energy can never be created or destroyed; except can be changed from one form to another with 1-1 exact equivalence. (WIV)
	CO	Explain Lenz's law. (Appendix XIII)		7V	When a current-carrying wire is placed in a magnetic field there are forces acting on the wire tending to push it at right angles to the direction of the field. The magnitude of these forces depends upon the magnetic polarity providing that the wire is not parallel to the field. (WSV)
	7V	Electromagnetic flow meter. (WSV)		7D	Electromagnetic flow meter is the transducer used to measure the flow of liquids which are conductors of electricity. (WSV)
	7A	A magnet always has at least two poles and is surrounded by a field of force. (WIRD)		7S	Give three methods of producing magnetic fields other than by the use of permanent magnets. (WSV)
	8A	Give three methods of reducing the attraction between two magnetic poles without diminishing the strength of the field. (WSV)		7I	The force of attraction or repulsion between two magnetic poles varies directly as the product of the strengths and inversely as the square of the distance between the poles. (WSV)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	20				Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W54)
	21				A magnet always has at least two poles and is surrounded by a field of force. (W159)
	16				The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W85)
Transmission and use of electricity					
Transformers	16				The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil. (W72)
	16				An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (W35)
*Electric lighting	25	What makes the light in an electric bulb? (Appendix A, Experiment XXIV)	D	24	Whenever electric currents flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (J9)

Topics	Value	Experiments	Lab. Table	Principles
	72			Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (604)
	81			A magnet always has at least two poles and is surrounded by a field of force. (710)
	10			The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (605)
Transformation and use of electricity Transformers	15			The amplitude of an induced e.m.f. is proportional to the ratio of ratio the number of turns of wire in the coil. (672)
	75			An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (685)
Electric lighting	20	What makes the light in an incandescent electric bulb? Appendix A, Experiment XXIV	1	64 Whenever electric current flows through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (690)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	25			25	When a substance is heated by electricity to a sufficiently high degree of temperature it glows, because a part of the heat energy has been transformed into light energy. (J11)
	21			21	Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W17)
	15			8	The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W15)
	11			19	All wires carrying an electric current resist the flow of the current. (J10)
	19			20	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
*Electric heating	23	Does a piece of wire have enough resistance to the flow of electricity through	L	23	All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
	8	it to produce heat? When current is flowing through a wire, does a long wire		11	The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W15)

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
	12	or a shorter wire of the same kind and size get warmer quicker? Does a larger wire or a		10	The resistance of a metallic conductor depends on the kind of material from which the conductor is made, varies directly with the length, inversely with the cross-sectional area, and increases as the temperature increases. (W80)
	20	small wire of the same kind and length get warmer quicker? Does one kind of wire get warmer quicker than a different kind of wire of the same size and length? (Appendix A, Experiment XXV)		20	Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
Electric appliances	20				Whenever electric currents flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (J9)
	22				All wires carrying an electric current resist the flow of the current. (J10)
	24				All materials offer some resistance to the flow of an electric current and that part of the

TABLE VIII (Continued)

Topics	Value	Experiments	LDX	Value	Principles
					electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
	14				Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)
	17				Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W17)
	9				When a current-carrying wire is placed in a magnetic field there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the magnetic poles, providing that the wire is not parallel to the field. (W94)
Electroplating	11				Positively charged ions of metals may be deposited on the cathode, as atoms, when a direct current is sent through an electrolyte. (W71)
	8				The mass of any substance set free by electrolysis is proportional to the current flowing and the time of flow; if the quantity of electricity is kept constant, the masses of the various substances set free are proportional to their electro-chemical equivalents. (W56)
Electrotyping	11				Positively charged ions of metals may be deposited on the cathode, as atoms, when a direct current

TABLE VIII (continued)

Topics	Verbs	Expressions	Adjectives	Prepositions
electrocution	to			

TABLE VIII (Concluded)

Topics	Value	Experiments	LDX	Value	Principles
					is sent through an electrolyte. (W71)
	8				The mass of any substance set free by electrolysis is proportional to the current flowing and the time of flow; if the quantity of electricity is kept constant, the masses of the various substances set free are proportional to their electro-chemical equivalents. (W56)
Safety and electricity		How can two wires be joined (spliced)? (Appendix A, Experiment XXVI)	L		No principle assigned.
Fuses	24	How does a fuse protect the house from fire? (Appendix A, Experiment XXVII)	D	22	All materials offer some resistance to the flow of an electric current and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)
	9			10	The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W15)
Other precautions					

Findings Table VIII. An examination of Table VIII shows that some topics such as Early Ideas of Magnetism did not lend themselves to development by means of an experiment. Other topics such as Magnetic Attraction have had three experiments suggested.

Table VIII also shows that the total values ranged from 5 to 25 in the judgment of the evaluators who marked the topic for suitability in helping to develop in general science at the eighth-grade level an understanding of the principle for which the topic was evaluated. The same range of total values, namely 5-25, was given by the evaluators to the experiments which were evaluated by them.

Table VIII further shows that the combined judgment of the second group of evaluators resulted in the placement of L after thirteen experiments, indicating appropriateness for performance as a laboratory experiment, the placement of D after eleven experiments, indicating appropriateness for performance as a demonstration, and the placement of X after three experiments, indicating equal appropriateness for performance as a laboratory experiment or as a demonstration.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This investigation was undertaken because it seemed desirable to determine for a general science course at the eighth-grade level a composite outline of subject-matter topics for the area Magnetism and Electricity, the experiments related to these topics and the scientific principles which could be defensibly assigned to the designated experiments.

The survey of related literature strengthened the investigator's conviction that a functional understanding of scientific principles was a worthy major goal of instruction of science at all grade levels and consequently an acceptable goal at the eighth-grade level. It was therefore undertaken as a part of the problem of this investigation to establish the functional understanding of scientific principles as one of the instructional aims in the specific area Magnetism and Electricity.

A careful evaluation of available suitable textual material resulted in the final selection of sixteen textbooks of general science, nine accompanying laboratory manuals or workbooks, and twelve teacher's manuals. Of the sixteen textbooks chosen, ten were written specifically for the eighth-grade level, five were general science textbooks intended for use in either grade seven, eight or nine

and one was a textbook written to present to teachers professionalized subject matter suitable for general science at the junior-high-school level. This textual material was subjected to several analyses which resulted in some very interesting conclusions.

The first of these conclusions was the establishing of the grade placement of the topics Magnetism and Electricity. The authors were almost unanimous in placing both these topics at the eighth-grade level.

However, the authors were far from unanimous in the emphasis they placed on these topics as judged by the space devoted to them. There was so little agreement among them as to the spatial importance of Magnetism that the range of pages devoted to this topic was from 0 - 14. The same situation was true in regard to the topic Electricity where the range of pages was even greater, namely from 0 - 79. Considered as a percentage of the entire book the number of pages devoted to both Magnetism and Electricity ranged from 0.0 percent in one book to 11.4 percent in two books.

An analysis of the textual material to determine the subject-matter topics for the area Magnetism and Electricity also revealed further lack of agreement among the authors. After a master topical outline had been compiled and later approved by a group of science teachers enrolled in a Seminar in Science Education at Boston University, the textual materials were once more analyzed to determine the method of presentation of the topics that were in this outline. Again there appeared to be lack of agreement among the authors. Some

topics were presented as topics in chapter, center and paragraph headings, some were implied by the text or by illustration and some were omitted. There was a tendency for the authors to state topics relating to Electricity as chapter, center and paragraph headings and to treat topics relating to Magnetism incidentally, merely implying them in the context or in an illustration.

When the textual materials were analyzed to determine which experiments relating to Magnetism and Electricity were included therein, special attention was given to the laboratory manuals. It was found that there was little uniformity in either the experiments incorporated in the laboratory manuals and textbooks or the manner of their presentation. When the composite experiments were formulated from the experiments found in the various laboratory manuals and textbooks an attempt was made to adhere to an identical form of presentation of the different experiments.

After the composite experiments had been written up, they were assigned to designated scientific principles which they represented. The majority of the science textbooks that were examined in this investigation either omitted scientific principles entirely or gave them very little importance.

In the two books, Book E and Book J, where a few scientific principles were definitely presented they were well expressed in language suitable for the eighth-grade level. In seven textbooks, there were lists of key statements or summaries that could very well have been rewritten as

minor scientific principles. The principles assigned to topics and composite experiments were taken from the lists of scientific principles formulated by Wise and by Jones. Only those principles were used which seemed to the investigator to be suitable for development at the eighth-grade level. It was not always possible to select from Wise's list principles that were stated in language appropriate for the eighth-grade level although most of the principles in Jones' list met this criterion. For this reason, it was considered proper in certain cases to follow a principle by Wise with a similar though less comprehensive one by Jones.

The composite experiments and related topics, having been assigned to designated principles, were then examined by the specialist in the teaching of science directing this investigation in order that the assignment of said principles might be validated. Some additions and deletions were made.

The assignment to designated principles of the composite experiments and related topics was then evaluated by five experienced teachers of general science, all members of a Seminar in Science Education, Boston University, 1946-47, and the topics that had no related experiments were marked by five other evaluators, all experienced teachers of general science at the eighth-grade level. There was a high correlation between the values given by the two sets of evaluators. In most cases principles that were stated in language appropriate for an eighth grade received

the highest score.

The second group of evaluators who gave their opinions as to the most appropriate method of performance of the composite experiments favored the laboratory method more than the demonstration method of presentation of these experiments. There was almost a unanimous choice of method although each evaluator worked independently.

The writer recommends the discussion of the topics in the topical outline presented herein for the area Magnetism and Electricity and the performance of the composite experiments related to the respective topics as a means of developing in eighth-grade pupils a functional understanding of the assigned scientific principles. The fact that there is a definite even though slight trend toward developing specific principles in textbooks of science at the eighth-grade level of instruction should encourage teachers of science at that grade level to seriously consider the development of a functional understanding of scientific principles as one of the major objectives of their science teaching.

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Watkins, Ralph K. and Perry, Winifred, Workbook to Science for Daily Use, New York: The Macmillan Company, 1943.
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APPENDIX A: COMPOSITE EXPERIMENTS

COMPOSITE EXPERIMENT I

Topic: Polarity

Question: What happens to a magnet when it is suspended by a string?

Principles: Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W*54)

When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J*5)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

References:

Book A, p. 375
Book B, p. 446
Book C, p. 460 Manual, p. 124
Book D, p. 196
Book F, p. 234 Manual, p. 103
Book G, p. 428
Book L, p. 386
Book N, p. 323
Book O, p. 416

*The W means that the principle was included as here stated in Wise's list of 264 principles of physical science suitable for general education, grades I - XIV, inclusive. The J means that the principle was included in Jones' list of science principles found in ninth-grade general science textbooks.

APPENDIX A: COMPOSITE EXPERIMENTS

COMPOSITE EXPERIMENT I

Topic: Polarity

Question: What happens to a magnet when it is suspended by a string?

Principles: Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W*5¢)

When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J*S)

A magnet always has at least two poles and is surrounded by a field of force. (H IS9)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (H 85)

References: Book A, p. 373
Book B, p. 446
Book C, p. 680 Manual, p. 124
Book D, p. 136
Book F, p. 234 Manual, p. 103
Book G, p. 438
Book L, p. 386
Book R, p. 888
Book O, p. 415

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*The * means that the principle was included as here stated in Wise's list of 884 principles of physical science suitable for general education. Grades I - XIV, inclusive. The J means that the principle was included in Jones' list of science principles found in ninth-grade general science textbooks.

COMPOSITE EXPERIMENT I

Question: What happens to a magnet when it is suspended by a string?

Materials: Bar magnet.
Silk thread.
Support (A stick about two feet long, fastened at right angles to the wall can be used.)

Procedure:

1. Tie a long silk thread around the middle of a bar magnet.
2. Hang it so that it will swing freely.
3. Let it come to rest. (Be sure that no other magnet or piece of iron or steel is near the magnet.)
4. In what directions is the magnet pointing?
5. Mark the end which points north with the letter N made by a piece of crayon or colored chalk.
6. As a check, repeat the experiment, using another magnet.
7. Mark the end which points north. Does this magnet point in the same direction as the other one?

Conclusion: When a bar magnet is hung up by a string so that it can turn freely, it will come to rest approximately in a north-and-south direction.

COMPOSITE EXPERIMENT I

Question: What happens to a magnet when it is suspended by a string?

Materials: Bar magnet.
Silk thread.
Support (A stick about two feet long, fastened at right angles to the wall can be used.)

Procedure:
1. Tie a long silk thread around the middle of a bar magnet.
2. Hang it so that it will swing freely.
3. Let it come to rest. (Be sure that no other magnet or piece of iron or steel is near the magnet.)
4. In what directions is the magnet pointing?
5. Mark the end which points north with the letter N made by a piece of crayon or colored chalk.
6. As a check, repeat the experiment, using another magnet.
7. Mark the end which points north. Does this magnet point in the same direction as the other one?

Conclusion: When a bar magnet is hung up by a string so that it can turn freely, it will come to rest approximately in a north-and-south direction.

COMPOSITE EXPERIMENT II

Topic: Magnetic Attraction

Question: What substances will a magnet attract?

Principles:

Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

References:

Book A, p. 375
Book B, p. 440
Book C, p. 459 Manual, p. 123
Book D, p. 197
Book E, p. 369 Manual, p. 95
Book F, p. 234 Manual, p. 103
Book G, p. 427
Book I, p. 459
Book L, p. 385
Book N, p. 322
Book O, p. 415

SUGGESTED ASSIGNMENT II

Topic: Magnetic Attraction

Question: What substances will a magnet attract?

Principles: Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W 107)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 96)

A magnet always has at least two poles and is surrounded by a field of force. (W 102)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (T 84)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (C 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

References: Book A, p. 375
Book E, p. 490
Book O, p. 459 Manual, p. 125
Book D, p. 197
Book E, p. 385 Manual, p. 96
Book F, p. 394 Manual, p. 105
Book G, p. 487
Book I, p. 459
Book L, p. 388
Book N, p. 382
Book O, p. 415

COMPOSITE EXPERIMENT II

Question: What substances will a magnet attract?

Materials: A magnet, either a bar magnet or a horseshoe magnet.
Several of the following substances:

Paper clip	*Needle
Rubber band	*Nail
A marble	Dime
Collar button	Tack
Match stick	Button
Pen point	Thimble
Piece of chalk	Key
Bit of glass	Eraser
Iron filings	Cent
Thumb tack	Stamp
Bits of cloth	Pin
Bobby pin	Wooden spool
Gold ring	Metal snap

(small pieces of *nickel and *cobalt)
*Try to have these four substances.

Procedure:

1. Make a chart on the blackboard. Pupils make a similar chart on paper.
   Have three columns, with these headings.
   Column I — Substance Tested
   Column II — Attracted by Magnet
   Column III — Not Attracted by Magnet

2. List all the substances to be tested in Column I.

3. Test the attraction of the magnet for each substance by touching each of the objects with the magnet.
   Note: The teacher ~~may~~ shall begin the testing and then have the pupils continue it.
   One pupil could do all the testing while the others recorded results.
   Each substance might be tested by a different pupil.

COMPOSITE EXPERIMENT II

Question: What substances will a magnet attract?

Materials: A magnet, either a bar magnet or a horseshoe magnet.
Several of the following substances:

Paper clip	*Needle
Rubber band	*Nail
A marble	Dime
Dollar button	Tack
Match stick	Button
Pen point	Thimble
Piece of chalk	Key
Bit of glass	Eraser
Iron filings	Cent
Thumb tack	Stamp
Bits of cloth	Pin
Bobby pin	Wooden spool
Gold ring	Metal snap

(small pieces of *nickel and *cobalt)
*Try to have these four substances.

Procedure:

1. Make a chart on the blackboard. Pupils make a similar chart on paper. Have three columns, with these headings.

Column I	Substance Tested
Column II	Attracted by Magnet
Column III	Not Attracted by Magnet

2. List all the substances to be tested in Column I.

3. Test the attraction of the magnet for each substance by touching each of the objects with the magnet.
Note: The teacher may begin the testing and then have the pupils continue it.
One pupil could do all the testing while the others recorded results.
Each substance might be tested by a different pupil.

COMPOSITE EXPERIMENT II (Concluded)

4. As the substance is tested have the pupils notice what happens.

5. If the magnet picks up the substance or attracts it at all put a check mark in Column II.

6. If the magnet does not pick up the substance or attract it put the check mark in Column III.

7. Study the completed chart.

8. The substances that were attracted by the magnet were made of - - -, - - -, - - - and - - -.

Conclusion: The substances that a magnet will attract are iron, steel, nickel and cobalt.

COMPOSITE EXPERIMENT II (Concluded)

6. As the substance is tested have the pupils notice what happens.

8. If the magnet picks up the substance or attracts it at all put a check mark in Column II.

8. If the magnet does not pick up the substance or attract it put the check mark in Column III.

7. Study the completed chart.

8. The substances that were attracted by the magnet were made of - - -, - - -, - - - and - - -.

Conclusion: The substances that a magnet will attract are iron, steel, nickel and cobalt.

COMPOSITE EXPERIMENT III

Topic: Magnetic Attraction

Question: What parts of a magnet have the greatest pulling power or magnetic force of attraction?

Principles: A magnet always has at least two poles and is surrounded by a field of force. (W 159)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

References:

Book A, p. 375
Book B, p. 440
Book C, p. 460 Manual, p. 123
Book D, p. 196
Book E, p. 369 Manual, p. 95
Book G, p. 428
Book N, p. 323
Book O, p. 416

CONCRETE EXPERIMENT III

Topic: Magnetic Attraction

Question: What parts of a magnet have the greatest pulling power or magnetic force of attraction?

Principles: A magnet always has at least two poles and is surrounded by a field of force. (M 159)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (M 85)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (M 102)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (M 84)

References: Book A, p. 376
Book B, p. 440
Book C, p. 430 Manual, p. 129
Book D, p. 186
Book E, p. 089 Manual, p. 98
Book G, p. 426
Book K, p. 333
Book O, p. 418

COMPOSITE EXPERIMENT III

Question: What parts of a magnet have the greatest pulling power?

Materials:
Bar magnet.
Horseshoe magnet.
Iron filings or nails.

Procedure:

1. Sprinkle some iron filings or nails evenly over a piece of paper.
2. Lay the bar magnet flat on the filings.
3. Lift it gently. To what parts of the magnet do most of the filings or nails cling?
4. Repeat the experiment, using a horseshoe magnet. To what parts of this magnet do most of the filings or nails cling?

Conclusion: A magnet has greater pulling power or magnetic force of attraction at the poles.

COMPOSITE EXPERIMENT III

Question: What parts of a magnet have the greatest pulling power?

Materials: Bar magnet.
Horseshoe magnet.
Iron filings or nails.

Procedure:
1. Sprinkle some iron filings or nails evenly over a piece of paper.
2. Lay the bar magnet flat on the filings.
3. Lift it gently. To what parts of the magnet do most of the filings or nails cling?
4. Repeat the experiment, using a horseshoe magnet. To what parts of this magnet do most of the filings or nails cling?

Conclusion: A magnet has greater pulling power or magnetic force of attraction at the poles.

COMPOSITE EXPERIMENT IV

Topic: Magnetic Attraction

Question: Can the magnetism be removed from a magnet by heating it or jarring it?

Principles:

Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 219)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

References:

Book B, p. 441
Book C, p. 460 Manual, p. 124
Book J Manual, p. 91

COMPOSITE EXPERIMENT IV

Topic: Magnetic attraction

Question: Can the magnetism be removed from a magnet by heating it or jarring it?

Principles: Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 512)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 514)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Pieces of iron, steel, nickel or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

References: Book B, p. 441
Book C, p. 460 Manual, p. 124
Book J Manual, p. 81

COMPOSITE EXPERIMENT IV

Question: Can the magnetism be removed from a magnet by heating it or by jarring it?

Materials:
Iron bolt.
Magnet.
Iron filings.
Pliers.
Heat.
Hammer.

Procedure:

1. Magnetize the bolt by stroking it with a magnet.
2. Test it with iron filings to prove that it is a magnet.
3. Holding the bolt with pliers, heat it red hot in a flame.
4. Let the bolt cool. Then test it. What do you find?
5. Again magnetize the bolt and test it for magnetism.
6. Strike the bolt several hard blows with a hammer.
7. Again test the bolt for magnetism. What do you find?

Conclusion: Magnets can be made to lose their magnetism by heating them or jarring them suddenly.

COMPOSITE EXPERIMENT IV

Question: Can the magnetism be removed from a magnet by heating it or by jarring it?

Materials: Iron bolt.
Magnet.
Iron filings.
Pliers.
Heat.
Hammer.

Procedure:
1. Magnetize the bolt by stroking it with a magnet.
2. Test it with iron filings to prove that it is a magnet.
3. Holding the bolt with pliers, heat it red hot in a flame.
4. Let the bolt cool. Then test it. What do you find?
5. Again magnetize the bolt and test it for magnetism.
6. Strike the bolt several hard blows with a hammer.
7. Again test the bolt for magnetism. What do you find?

Conclusion: Magnets can be made to lose their magnetism by heating them or jarring them suddenly.

COMPOSITE EXPERIMENT V

Topic: Magnetic Field

Question: What is the nature of the magnetic field of force that surrounds a magnet?

Principles: A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

References:

Book A, p. 375
Book B, p. 444
Book C, p. 460 Manual, p. 125
Book D, p. 199
Book E, p. 370 Manual, p. 96
Book F, p. 236 Manual, p. 103
Book G, p. 431
Book L, p. 389
Book N, p. 323
Book O, p. 417

COMPOSITE EXPERIMENT V

Topic: Magnetic Field

Question: What is the nature of the magnetic field of force that surrounds a magnet?

Principles: A magnet always has at least two poles and is surrounded by a field of force. (W 189)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 45)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 103)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 34)

References: Book A, p. 575
Book B, p. 444
Book C, p. 480 Manual, p. 123
Book D, p. 189
Book E, p. 270 Manual, p. 36
Book F, p. 236 Manual, p. 103
Book G, p. 431
Book L, p. 385
Book M, p. 825
Book O, p. 417

COMPOSITE EXPERIMENT V

Topic

Question: What is the nature of the magnetic field of force that surrounds a magnet?

Introduction

Materials:
Bar magnet.
U-shaped magnet.
Sheet of stiff paper.
Iron filings.

Procedure:

1. Place the bar magnet on the table between two books that are a little thicker than the magnet.
2. Place the piece of stiff paper on the books.
3. Sprinkle iron filings evenly over the paper.
4. Gently tap the paper, noticing the pattern the filings take.
5. Repeat the experiment, using the U-shaped magnet.
6. Did the magnetism pass through the paper?
7. Notice the pattern that the filings take.

Conclusion: Magnetism extends in all directions from a magnet through the space around it. This space in which the magnet acts is called the magnetic field.

DEMONSTRATION EXPERIMENT V

Question: What is the nature of the magnetic field of force that surrounds a magnet?

Materials: Bar magnet.
U-shaped magnet.
Sheet of stiff paper.
Iron filings.

Procedure: 1. Place the bar magnet on the table between two books that are a little thicker than the magnet.

2. Place the piece of stiff paper on the books.

3. Sprinkle iron filings evenly over the paper.

4. Gently tap the paper, noticing the pattern the filings take.

5. Repeat the experiment, using the U-shaped magnet.

6. Did the magnetism pass through the paper?

7. Notice the pattern that the filings take.

Conclusion: Magnetism extends in all directions from a magnet through the space around it. This space in which the magnet acts is called the magnetic field.

COMPOSITE EXPERIMENT VI

Topic: Magnetic Lines of Force

Question: How can a permanent record of a magnetic field showing the "lines of force" be made?

Principles:

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

References:

Book A, p. 375
Book B, p. 443
Book C Manual, p. 125
Book D, p. 199
Book E, p. 370
Book G, p. 431
Book L, p. 389
Book N, p. 323
Book O, p. 417

COMPOSITE EXPERIMENT VI

Topic: Magnetic lines of force

Question: How can a permanent record of a magnetic field showing the "lines of force" be made?

Principles: A magnet always has at least two poles and is surrounded by a field of force. (W 139)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 108)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 84)

References: Book A, p. 375
Book B, p. 442
Book C Manual, p. 125
Book D, p. 189
Book E, p. 370
Book G, p. 431
Book L, p. 389
Book N, p. 385
Book O, p. 417

COMPOSITE EXPERIMENT VI

Question: How can a permanent record of a magnetic field showing the "lines of force" be made?

Materials:
Bar magnet.
Horseshoe magnet.
Iron filings.
Paraffin.
Long shallow oblong cake tin.
Source of heat.

Procedure:

1. Place the bar magnet on a sheet of paper and trace the outline of it.
2. Melt enough paraffin in the cake tin to fill it to the depth of half an inch.
3. Dip the sheet of paper in the hot paraffin.
4. Lift it out by one corner and hold it until it is hard.
5. Lay this sheet over the bar magnet so that the outline of the bar magnet is over the bar magnet.
6. Sift iron filings over the paper.
7. Gently tap the paper with a pencil.
8. The filings will arrange themselves in lines called "lines of force".
9. Carefully lift the paper horizontally.
10. Hold it over a lamp or gas burner until the paraffin melts.

COMPOSITE EXPERIMENT VI

Question: How can a permanent record of a magnetic field showing the "lines of force" be made?

Materials: Bar magnet.
Horseshoe magnet.
Iron filings.
Paraffin.
Long shallow oblong cake tin.
Source of heat.

Procedure:

1. Place the bar magnet on a sheet of paper and trace the outline of it.

2. Melt enough paraffin in the cake tin to fill it to the depth of half an inch.

3. Dip the sheet of paper in the hot paraffin.

4. Lift it out by one corner and hold it until it is hard.

5. Lay this sheet over the bar magnet so that the outline of the bar magnet is over the bar magnet.

6. Sift iron filings over the paper.

7. Gently tap the paper with a pencil.

8. The filings will arrange themselves in lines called "lines of force".

9. Carefully lift the paper horizontally.

10. Hold it over a lamp or gas burner until the paraffin melts.

COMPOSITE EXPERIMENT VI (Concluded)

11. Remove paper from the heat but keep it horizontal until the paraffin hardens again.

12. Repeat entire procedure with the horseshoe magnet.

Conclusion: A permanent record of the magnetic field filled with the "lines of force" which cause magnetic substances to be attracted by a magnet can be made by sifting iron filings on dry paraffined paper, melting the paraffin and letting the paraffin harden.

COMPOSITE EXPERIMENT VI (Continued)

11. Remove paper from the heat and keep it horizontal until the paraffin hardens again.

12. Repeat entire procedure with the horseshoe magnet.

Conclusion: A permanent record of the magnetic field filled with the "lines of force" which cause magnetic substances to be attracted by a magnet can be made by sifting iron filings on dry paraffined paper, melting the paraffin and letting the paraffin harden.

COMPOSITE EXPERIMENT VII

Topic: Induced Magnetism

Question: How can a magnet be made by induction?

Principles: Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 219)

Magnetic energy, or magnetism extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

References:

Book B, p. 442	
Book C	Manual, p. 124
Book D, p. 198	
Book E, p. 370	Manual, p. 96
Book G, p. 434	
Book N, p. 324	

COMPOSITE EXPERIMENT VII

Topic: Induced magnetism

Question: How can a magnet be made by induction?

Principles: Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 219)

Magnetic energy, or magnetism extends in all directions from a magnet through the space around it. (J 1)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 55)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 64)

References: Book B, p. 442
Book C Manual, p. 184
Book D, p. 158
Book E, p. 272 Manual, p. 36
Book G, p. 434
Book N, p. 284

COMPOSITE EXPERIMENT VII

Question: How can a magnet be made by induction?

Materials:
Bar magnet.
U-shaped magnet.
Iron filings.
Large nail.

Procedure:

1. Pick up the nail with the bar magnet.
2. Dip the nail which is clinging to the magnet into some iron filings.
3. Does the nail attract the iron filings?
4. Now pull the nail away from the magnet. What happens to the iron filings?
5. The nail which was made of soft iron was magnetized temporarily.
6. The nail became a temporary magnet. When did the nail lose its magnetism?

Conclusion: A magnet can be made by induction by bringing a piece of iron near a magnet.

COMPOSITE EXPERIMENT VII

Question: How can a magnet be made by induction?

Materials: Bar magnet.
U-shaped magnet.
Iron filings.
Large nail.

Procedure:
1. Pick up the nail with the bar magnet.
2. Dip the nail which is clinging to the magnet into some iron filings.
3. Does the nail attract the iron filings?
4. How pull the nail away from the magnet. What happens to the iron filings?
5. The nail which was made of soft iron was magnetized temporarily.
6. The nail became a temporary magnet. When did the nail lose its magnetism?

Conclusion: A magnet can be made by induction by bringing a piece of iron near a magnet.

COMPOSITE EXPERIMENT VIII

Topic: Law of Magnetic Poles

Question: What happens when the same kinds and different kinds of poles of two magnets, one of which is free to move, are brought near each other?

Principles: Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

References:

Book A, p. 375
Book B, p. 442
Book C, p. 460 Manual, p. 124
Book D, p. 197
Book E, p. 369 Manual, p. 95
Book F, p. 234 Manual, p. 103
Book G, p. 430
Book J, p. 192
Book L, p. 386
Book N, p. 323

COMPOSITE EXPERIMENT VIII

Topic: Law of Magnetic Poles

Question: What happens when the same kinds and different kinds of poles of two magnets, one of which is free to move, are brought near each other?

Principles: Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 34)

A magnet always has at least two poles and is surrounded by a field of force. (W 152)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

References: Book A, p. 375
Book B, p. 462
Book C, p. 460 Manual, p. 124
Book D, p. 197
Book E, p. 389 Manual, p. 95
Book F, p. 256 Manual, p. 103
Book G, p. 430
Book J, p. 192
Book L, p. 386
Book N, p. 325

COMPOSITE EXPERIMENT VIII

Question: What happens when the same kinds and different kinds of poles of two magnets, one of which is free to move, are brought near each other?

Materials: Two bar magnets on which the north and south poles are marked; a piece of string; a bent-hook stand or a wooden arm that has been attached at right angles to the wall.

Procedure:

1. Label one bar magnet A and the other one B.
2. Hang up bar magnet A by a piece of string so that it can swing about freely. Let it come to rest.
   Note: A bar magnet hung so that it can turn freely will always point north and south.
3. Bring the north pole of magnet B near the north pole of magnet A. What happens?
4. After the suspended magnet A has come to rest again, bring the south pole of magnet B near the north pole of magnet A. What happens?
5. Test the south pole of the suspended magnet A with both poles of magnet B. What happens in each test?
6. As a check experiment repeat procedures 3, 4 and 5 until you are certain you know exactly what occurs.
7. When the magnets cling together we say they - - - - each other. When they push each other away we say they - - - - each other.

Conclusion: Like magnetic poles repel each other and unlike magnetic poles attract each other.

EXPERIMENT VIII

Question: What happens when the same kinds and different kinds of poles of two magnets, one of which is free to move, are brought near each other?

Materials: Two bar magnets on which one north and south poles are marked; a piece of string; a beaker, book stand or a wooden clip that has been attached at right angles to the wall.

Procedure:

1. Label one bar magnet A and the other one B.

2. Hang up bar magnet A by a piece of string so that it can swing about freely. Let it come to rest.
   Note: A bar magnet hung so that it can turn freely will always point north and south.

3. Bring the north pole of magnet B near the north pole of magnet A. What happens?

4. After the suspended magnet A has come to rest again, bring the south pole of magnet B near the north pole of magnet A. What happens?

5. Test the south pole of the suspended magnet A with both poles of magnet B. What happens in each test?

6. As a check experiment repeat procedures 3, 4 and 5 until you are certain you know exactly what occurs.

7. When the magnets cling together we say they - - - - each other. When they push each other away we say they - - - - each other.

Conclusion: Like magnetic poles repel each other and unlike magnetic poles attract each other.

Composite Experiment IX

Topic: Magnetic Compass

Question: How can a magnetic compass be made?

Principles:

When a magnet is allowed to float or swing freely it will turn until it points north and south. (J 5)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 219)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

References:

Book A, p. 376
Book B, p. 447
Book C, p. 460 Manual, p. 123
Book D, p. 197
Book E, p. 369 Manual, p. 95
Book F, p. 237 Manual, p. 104
Book G, p. 429
Book I, p. 222
Book K, p. 191
Book L, p. 386
Book O, p. 416

Demonstrable Experiment IX

Topic: Magnetic Dompans.

Question: How can a magnetic compass be made?

Principles: When a magnet is allowed to float or swing freely it will turn until it points north and south. (J 3)

Like magnetic poles always repel and other and unlike magnetic poles always attract each other. (W 54)

A magnet always has at least two poles and is surrounded by a field of force. (W 102)

Magnets depend for their properties upon the arrangement of the metallic tone of which they are made. (W 319)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 55)

Any magnet has no lines of force about the poles of the magnet. (J 5)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

References: Book A, p. 372
Book E, p. 447
Book O, p. 400 Manual, p. 133
Book D, p. 187
Book S, p. 369 Manual, p. 85
Book K, p. 427 Manual, p. 104
Book G, p. 489
Book I, p. 222
Book K, p. 191
Book L, p. 388
Book O, p. 416

COMPOSITE EXPERIMENT IX

Question: How can a magnetic compass be made?

Introduction

Materials: Steel sewing needle (the long type used for embroidering is good).
Small cork.
Magnet - either bar or U-shaped.
Tumbler or porcelain vessel (cup) partly filled with water.

Procedure:

1. Magnetize the sewing needle by stroking it with the bar or U-shaped magnet. Always begin stroking it at one end of the needle and stroke each time in the same direction.
2. Push the needle (which is now a bar magnet) through the cork.
3. Place the cork in the partly filled tumbler of water so that the needle will float above the surface of the water.
4. Answer these questions:
   a. Does the needle turn around until it points in any certain direction?
   b. If it does so turn, in which direction?
   c. Move the needle in different directions. Will it turn of itself so as to point in another direction?
   d. Does the floating needle act like a compass? Why?
   e. Could an iron vessel be used instead of a glass or porcelain vessel? Why?

Conclusion: A magnetic compass can be made by inserting a magnetized needle in a small cork and floating it on the surface of water.

COMPOSITE EXPERIMENT IX

Question: How can a magnetic compass be made?

Materials: Steel sewing needle (the long type used for embroidering is good).
Small cork.
Magnet - either bar or U-shaped.
Tumbler or porcelain vessel (cup) partly filled with water.

Procedure:

1. Magnetize the sewing needle by stroking it with the bar or U-shaped magnet. Always begin stroking it at one end of the needle and stroke each time in the same direction.

2. Push the needle (which is now a bar magnet) through the cork.

3. Place the cork in the partly filled tumbler of water so that the needle will float above the surface of the water.

4. Answer these questions:

   a. Does the needle turn around until it points in any certain direction?

   b. If it does so turn, in which direction?

   c. Move the needle in different directions. Will it turn of itself so as to point in another direction?

   d. Does the floating needle act like a compass? Why?

   e. Could an iron vessel be used instead of a glass or porcelain vessel? Why?

Conclusion: A magnetic compass can be made by inserting a magnetized needle in a small cork and floating it on the surface of water.

COMPOSITE EXPERIMENT X

Topic: The Dipping Needle

Question: How can the action of the dipping needle be illustrated?

Principles:

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

When a magnet is allowed to float or swing freely, it will turn until it points north and south. (J 5)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Magnets depend for their properties upon the arrangement of the metallic ions of which they are made. (W 219)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

References:

Book B, p. 444
Book D, p. 200
Book F, p. 164

COMPOSITE EXPERIMENT X

Question: How can the action of the dipping needle be illustrated?

Materials:
Two steel knitting needles.
A cork.
A large pin.
Two glass cups.

Procedure:

1. Stick the needles half their length through the cork, at right angles to each other.
2. Set the cups a short distance apart.
3. Place the ends of one needle on the cups in such a way that the second needle balances and points north and south.
4. If the second needle doesn't balance, stick a pin in the cork so as to make it balance.
5. Lift off the device (the needles, cork and pin) and magnetize the balanced needle.
6. Replace the device in the same position.
7. What happens to the north pole of the magnetized needle?

Conclusion: The action of the dipping needle may be illustrated by the dipping of the north pole of a magnetized needle that has been balanced so as to permit it to swing up and down vertically.

COMPOSITE EXPERIMENT X

Question: How can the action of the dipping needle be illustrated?

Materials: Two steel knitting needles;
A cork.
A large pin.
Two glass cups

Procedure:
1. Stick the needles half their length through the cork, at right angles to each other.

2. Set the cups a short distance apart.

3. Place the ends of one needle on the cups in such a way that the second needle balances and points north and south.

4. If the second needle doesn't balance, stick a pin in the cork so as to make it balance.

5. Lift off the device (the needles, cork and pin) and magnetize the balanced needle.

6. Replace the device in the same position.

7. What happens to the north pole of the magnetized needle?

Conclusion: The action of the dipping needle may be illustrated by the dipping of the north pole of a magnetized needle that has been balanced so as to permit it to swing up and down vertically.

COMPOSITE EXPERIMENT XI

Topic: Relation of Magnetism to Electricity

Question: How does an electric current flowing through a horizontal wire affect a compass needle under or above and parallel to the wire?

Principles: An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W 11)

Pieces of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

References:
Book A, p. 375
Book B, p. 439
Book E, p. 385 Manual, p. 102
Book O, p. 418
Book N, p. 325

COMPOSITE EXPERIMENT XI

Topic: Relation of Magnetism to Electricity

Question: How does an electric current flowing through a horizontal wire affect a compass needle under or above and parallel to the wire?

Principles: A cylindrical object in motion produces a magnetic field about the conductor. The direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W. 11)

Places of iron, steel, cobalt or nickel may become magnetized by induction when placed within a magnetic field. (W 103)

References: Book A, p. 375
Book B, p. 429
Book E, p. 385 Manual, p. 108
Book C, p. 413
Book Z, p. 325

COMPOSITE EXPERIMENT XI

Question: How does an electric current flowing through a horizontal wire affect a compass needle under or above and parallel to the wire?

Materials:
Compass.
Dry cell.
Piece of copper wire (about 3 feet long).

Procedure:

1. Attach the two ends of the copper wire to a dry cell.
2. Hold the wire taut with both hands just above the compass needle and parallel (not crosswise) to the needle.
3. What happens to the needle?
4. Turn the wire around so that it is still parallel but with its ends in the opposite direction.
5. What happens to the needle?

Conclusion: A horizontal wire carrying an electric current causes a compass needle under or above it to move until it is perpendicular instead of parallel to the wire.

COMPOSITE EXPERIMENT XII

Topic: Static or Frictional Electricity

Question: Can electric sparks be produced by shuffling the feet on a carpet and then touching something?

Principles: An electric current may be produced in three ways: by rubbing or friction, by chemical action, and by the use of a magnetic field. (W 47)

In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W 90)

Like electrical charges repel and unlike electrical charges attract. (W 23)

References:

Book A, p. 367	
Book B, p. 454	
Book C	Manual, p. 115
Book D, p. 203	
Book E, p. 372	Manual, p. 97
Book F, p. 228	Manual, p. 99
Book K, p. 189	
Book O, p. 416	

EXPERIMENT VII

Topic: Static or Frictional Electricity

Question: Can electric sparks be produced by rubbing the fist on a carpet and then touching some-thing?

Principles: An electric current may be produced in three ways: by rubbing or friction, by chemical action, and by the use of a magnetic field. (¶ 47)

In an uncharged body there are as many protons as electrons and the charges neutralize each other with a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (¶ 50)

Like electrical charges repel and unlike electrical charges attract. (¶ 52)

References:

Book A, p. 287
Book E, p. 454
Book O, Manual, p. 110
Book D, p. 203
Book E, p. 272 Manual, p. 37
Book F, p. 235 Manual, p. 38
Book K, p. 132
Book O, p. 416

COMPOSITE EXPERIMENT XII

Question: Can electric sparks be produced by shuffling the feet on a carpet and then touching something?

Materials: Rug or carpet.
Clear cold day.

Procedure:

1. Shuffle over a rug or carpet.
2. Then bring a finger near a metal object such as a radiator or near another person's ear.
3. What happens?
4. What other experience have you had with electric sparks?
5. What weather conditions are best for producing electric sparks?

Conclusion: Electric sparks due to friction can be produced by shuffling the feet on a carpet and then touching something.

COMPOSITE EXPERIMENT XII

Question: Can electric sparks be produced by shuffling the feet on a carpet and then touching something?

Materials: Rug or carpet.
Clear cold day.

Procedure: 1. Shuffle over a rug or carpet.

2. Then bring a finger near a metal object such as a radiator or near another person's ear.

3. What happens?

4. What other experiences have you had with electric sparks?

5. What weather conditions are best for producing electric sparks?

Conclusion: Electric sparks due to friction can be produced by shuffling the feet on a carpet and then touching something.

COMPOSITE EXPERIMENT XIII

Topic: Static or Frictional Electricity

Question: How can static or frictional electricity be produced?

Principles: An electric current may be produced in three ways: by rubbing or friction, by chemical action, and by the use of a magnetic field. (W 47)

In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W 90)

Like electrical charges repel and unlike electrical charges attract. (W 23)

References:

Book A, p. 367	
Book B, p. 454	
Book C, p. 443	Manual, p. 115
Book D, p. 204	
Book E, p. 372	Manual, p. 97
Book F, p. 228	Manual, p. 99
Book K, p. 190	
Book O	Manual, p. 220

COMPOSITE EXPERIMENT XIII

Question: How can static or frictional electricity be produced?

Materials: Some tiny pieces of paper.
A glass rod.
A hard rubber rod (a fountain pen or comb may be used if they are made of hard rubber).
A piece of fur.
A piece of silk.
A piece of woolen cloth.

Procedure:

1. Touch the bits of paper with the glass rod. What happens?
2. Rub the rod briskly with the piece of fur.
3. Now touch the bits of paper with the rod. What happens?
4. Repeat this test using the glass rod rubbed with the piece of silk and the hard rubber rod rubbed with the piece of fur and then rubbed with the piece of silk.
5. What happens each time?
6. When rubbing a substance gives it the property of attracting other light bodies we say the substance has been electrified by - - - -.
7. The electricity produced is called - - - - electricity.

Conclusion: Static or frictional electricity can be produced by rubbing or friction.

COMPOSITE EXPERIMENT XIV

Topic: Static or Frictional Electricity

Question: How do different kinds of electrical charges act toward one another?

Principles: Like electrical charges repel and unlike electrical charges attract. (W 23)

An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge and an excess of electrons produces a negative charge. (W 90)

References:

Book A, p. 368
Book B, p. 454
Book C, p. 433 Manual, p. 116
Book D, p. 204
Book E, p. 373 Manual, p. 103
Book K, p. 190
Book N, p. 329

COMPOSITE EXPERIMENT XIV

Topic: Static or Frictional electricity.

Question: How do different kinds of electrical charges act toward one another?

Materials:
Needle.
Hard rubber comb or pen.
Silk thread.
Bit of cork.
Piece of woolen cloth.
Support.

Procedure:

1. Thread the needle with the silk thread.
2. String the bit of cork on the silk thread and suspend it from the support.
3. Electrify the pen or comb and the woolen cloth by rubbing the pen briskly with the cloth.
4. Touch the cork with the pen so that the cork will have some of the same charge of electricity that was on the pen.
5. Now bring the minus-charged pen near the minus-charged cork.
6. Do the two minus charges attract each other or repel each other?
7. Again rub the pen briskly with the woolen cloth.
8. Charge the cork by allowing it to touch the pen.
9. Now bring the plus-charged cloth near the minus-charged cork.
10. Do the unlike charges attract each other or repel each other?

Conclusion: Electric charges of the same kind repel each other. Electric charges of opposite kinds attract each other.

DEMONSTRATION EXPERIMENT XIV

Question: How do different kinds of electrical charges act toward one another?

Materials: Needle.
Hard rubber comb or pen.
Silk thread.
Bit of cork.
Piece of woolen cloth.
Support.

Procedure:
1. Thread the needle with the silk thread.
2. String the bit of cork on the silk thread and suspend it from the support.
3. Electrify the pen or comb and the woolen cloth by rubbing the pen briskly with the cloth.
4. Touch the cork with the pen so that the cork will have some of the same charge of electricity that was on the pen.
5. Now bring the minus-charged pen near the minus-charged cork.
6. Do the two minus charges attract each other or repel each other?
7. Again rub the pen briskly with the woolen cloth.
8. Charge the cork by allowing it to touch the pen.
9. Now bring the plus-charged cloth near the minus-charged cork.
10. Do the unlike charges attract each other or repel each other?

Conclusion: Electric charges of the same kind repel each other. Electric charges of opposite kinds attract each other.

COMPOSITE EXPERIMENT XV

Topic: Conductors and Insulators

Question: How can substances be tested to see if they are conductors or non-conductors (insulators) of electricity?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 21)

All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W 43)

References:

Book A, p. 368
Book B, p. 459
Book C, p. 446
Book D, p. 205
Book E, p. 378
Book F, Manual, p. 99
Book G, p. 445
Book J, p. 202
Book K, p. 192
Book O, p. 424 Manual, p. 222

COMPOSITE EXPERIMENT XV

Topic: Conductors and Insulators

Question: How can substances be tested to see if they are conductors or non-conductors (insulators) of electricity?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a corroding solution, the more active metal being charged negatively. (W 18)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 81)

All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W 43)

References: Book A, p. 388
Book B, p. 458
Book C, p. 449
Book D, p. 205
Book E, p. 376
Book F, Manual, p. 99
Book G, p. 445
Book J, p. 203
Book K, p. 189
Book O, p. 454 Manual, p. 232

Composite Experiment XV

Question: How can substancesbe tested to see if they are conductors or non-conductors (insulators) of electricity?

Materials: Electric bell connected by bare wires to one or more dry cells. Several of the following substances:
iron, steel, copper, brass, silver, painted and bare metal objects, paper, paper clips, porcelain, glass, carbon (lead from a pencil will do), chalk, wood, rubber, wool, paraffin.

Some of these solutions:
pure water in a clean glass, pure water with a handful of table salt added, lemon juice or vinegar in water, baking or washing soda in water.

Procedure:

1. Test the circuit by ringing the bell. Explain that the current is flowing through the closed circuit.

2. Break the circuit by cutting one of the wires a short distance from the dry cell.

3. Now try the bell. It does not ring because - - - -.

4. Explain that if any of the substances conduct electricity across this break the bell will ring.

5. Test each substance by touching the bare ends of the wire to two points on the substance.

6. When the bell rings the substance tested is a - - - -.

7. When the bell does not ring the substance tested is a - - - - conductor or even a - - - - conductor.

Composite Experiment XV

Question: How can substances be tested to see if they are conductors or non-conductors (insulators) of electricity?

Materials: Electric bell connected by bare wires to one or more dry cells. Several of the following substances:
iron, steel, copper, brass, silver, painted and bare metal objects, paper, paper clips, porcelain, glass, carbon (lead from a pencil will do), chalk, wood, rubber, wool, paraffin.

Some of these solutions:
pure water in a clean glass, pure water with a handful of table salt added, lemon juice or vinegar in water, baking or washing soda in water.

Procedure:
1. Test the circuit by ringing the bell. Explain that the current is flowing through the closed circuit.

2. Break the circuit by cutting one of the wires a short distance from the dry cell.

3. Now try the bell. It does not ring because - - - -.

4. Explain that if any of the substances conduct electricity across this break the bell will ring.

5. Test each substance by touching the bare ends of the wire to two points on the substance.

6. When the bell rings the substance tested is a - - - -.

7. When the bell does not ring the substance tested is a - - - - conductor or even a - - - - conductor.

COMPOSITE EXPERIMENT XV (Concluded)

8. Another name for a nonconductor is an - - - -.

Conclusion: In general, the metals and some solutions such as - - - - are good conductors; the nonmetals (except carbon) and some solutions such as - - - - are poor conductors or insulators.

COMPOSITE EXPERIMENT XV (Concluded)

8. Another name for a nonconductor is an - - - - -.

Conclusion: In general, the metals and some solutions such as - - - - - are good conductors; the nonmetals (except carbon) and some solutions such as - - - - - are poor conductors or insulators.

COMPOSITE EXPERIMENT XVI

Topic: The Electric Circuit

Question: What is an electric circuit?

Principles: An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

All electric cells change chemical energy into electrical energy. (J 2)

References:
Book B, p. 467
Book C, p. 439 Manual, p. 117
Book D, p. 208
Book E, p. 380
Book G, p. 445
Book I, p. 352
Book J, p. 195
Book L, p. 394
Book O, p. 423

EXPERIMENT XVI

Topic: The Electric Circuit

Question: What is an electric circuit?

Principles: An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

All electric cells change chemical energy into electrical energy. (J 8)

References: Book B, p. 467
Book C, p. 439 Manual, p. 117
Book D, p. 208
Book E, p. 380
Book G, p. 445
Book I, p. 352
Book J, p. 135
Book L, p. 384
Book O, p. 439

COMPOSITE EXPERIMENT XVI

Question: What is an electric circuit?

Materials: A dry cell.
Two pieces of copper wire (no. 18)
An electric bell

Procedure:

1. Connect one wire from either pole (binding post) of the dry cell to the bell. Caution: Do not connect a wire to the zinc binding post on the cover of the dry cell and to the carbon in the center, for that will short circuit the cell and ruin it.

2. Does the bell ring?

3. Now connect the other wire to the other binding post of the dry cell and to the other post of the bell.

4. Does the bell ring?

Conclusion: The electric current makes a complete circuit from the cell, through the bell, and back to the cell.

COMPOSITE EXPERIMENT XVII

Topic: The Simple Galvanic Cell

Question: Can a simple cell consisting of two different metals separated by an acid solution produce an electric current?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

All electric cells change chemical energy into electrical energy. (J 2)

References:

Book A,	p. 372	
Book B,	p. 461	
Book C,	p. 440	Manual, p. 117
Book D,	p. 209	
Book E,	p. 382	Manual, p. 101
Book F,	p. 229	
Book G,	p. 444	
Book N,	p. 328	
Book O,		Manual, p. 221

COMPOSITE EXPERIMENT XVII

Question: Can a simple cell consisting of two different metals separated by an acid solution produce an electric current?

Materials:
A glass jar.
A strip of zinc (about 4" x 3").
A strip of copper.
Sulphuric acid.
Two copper wires.
Small electric bell.

Procedure:

1. In the jar make a solution of 4 parts water and one part acid.
   Caution: In diluting sulphuric acid with water always pour the acid into the water. Never pour water into acid, for the acid may be blown in your face.

2. Connect the electric bell to the metal strips. Be sure the ends of the wires are bare so that the bright copper touches the metal plates.

3. Lower the zinc and copper strips into the acid solution.

4. Does the bell ring? - - - -.

Conclusion: A simple cell consisting of two different metals separated by an acid solution produces an electric current. The ringing of the bell is proof of the current.

EXPERIMENT XVII

Question: Can a simple cell consisting of two different metals separated by an acid solution produce an electric current?

Materials:
A glass jar.
A strip of zinc (about ½" x 3").
A strip of copper.
Sulphuric acid.
Two copper wires.
Small electric bell.

Procedure:
1. In the jar make a solution of 4 parts water and one part acid.
   Caution: In diluting sulphuric acid with water always pour the acid into the water. Never pour water into acid, for the acid may be blown in your face.
2. Connect the electric bell to the metal strips. Be sure the ends of the wires are bare so that the bright copper touches the metal plates.
3. Lower the zinc and copper strips into the acid solution.
4. Does the bell ring? - - - -.

Conclusion: A simple cell consisting of two different metals separated by an acid solution produces an electric current. The ringing of the bell is proof of the current.

COMPOSITE EXPERIMENT XVIII

Topic: The Dry Cell

Question: How is a dry cell constructed and what seems to have happened inside a dry cell when it produced electricity?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

All electric cells change chemical energy into electrical energy. (J 2)

References:
Book A, p. 372
Book B, p. 462
Book C, p. 448
Book D, p. 209
Book E, p. 383
Book L, p. 385
Book N, p. 331
Book O, p. 422

COMPOSITE EXPERIMENT XVIII

Topic: The Dry Cell

Question: How is a dry cell constructed and what seems to have happened inside a dry cell when it produced electricity?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively. (W 18)

All electric cells change chemical energy into electrical energy. (1 2)

References: Book A, p. 372
Book B, p. 482
Book C, p. 448
Book D, p. 309
Book E, p. 383
Book F, p. 386
Book K, p. 391
Book O, p. 422

COMPOSITE EXPERIMENT XVIII

Question: How is a dry cell constructed and what seems to have happened inside a dry cell when it produced electricity?

Materials:
A worn-out dry cell.
A knife.
A hammer.
Large newspaper.

Procedure:

1. Remove the pasteboard cover of the dry cell.
2. Look at the terminals on the top.
3. Notice the sealing compound made of pitch or rosin sealing wax. This is an insulator. Does electricity pass through it?
4. Spread out the newspaper. With a hammer, break out the sealing compound.
5. Examine the zinc can. The white powdery substance on the outside of the zinc is called zinc chloride.
6. Cut open the can with a knife and remove the carbon rod.
7. Is the black mixture moist or dry? A dry cell is dry only on the - - - -. If the inside becomes dry the cell is "dead".
8. The black mixture contains chemical substances (sal ammoniac or ammonium chloride, powdered carbon, zinc chloride, and manganese dioxide).
9. When a wire connects the carbon terminal with the zinc terminal electricity flows.

Conclusion: A dry cell is constructed of a zinc cup for an outer terminal and a carbon rod for an inner terminal. The zinc cup and the carbon rod are separated by moist chemicals some of which act on the zinc cup and use it when electricity is produced by the dry cell.

COMPOSITE EXPERIMENT XVIII

Question: How is a dry cell constructed and what seems to have happened inside a dry cell when it produces electricity?

Materials: A worn-out dry cell.
A knife.
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Large newspaper.

Procedure:

1. Remove the pasteboard cover of the dry cell.

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3. Notice the sealing compound made of pitch or rosin sealing wax. This is an insulator. Does electricity pass through it?

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5. Examine the zinc can. The white powdery substance on the outside of the zinc is called zinc chloride.

6. Cut open the can with a knife and remove the carbon rod.

7. Is the black mixture moist or dry? A dry cell is dry only on the - - - -. If the inside becomes dry the cell is "dead".

8. The black mixture contains chemical substances (sal ammoniac or ammonium chloride, powdered carbon, zinc chloride, and manganese dioxide).

9. When a wire connects the carbon terminal with the zinc terminal electricity flows.

Conclusion: A dry cell is constructed of a zinc cup for an outer terminal and a carbon rod for an inner terminal. The zinc cup and the carbon rod are separated by moist chemicals some of which act on the zinc cup and use it when electricity is produced by the dry cell.

COMPOSITE EXPERIMENT XIX

Topic: Series and Parallel Connections

Question: How are dry cells connected in series and in parallel? Is more, the same or lese current available at any one time when dry cells are connected in series instead of in parallel?

Principles: In a series circuit the current is the same in all parts, the resistance of the whole is the sum of the resistance of the parts, and the voltage loss of the whole is the sum of the voltage losses of the parts. (W 139)

In a parallel circuit the total current is the sum of the separate currents, the voltage loss is the same for each branch, and the total resistance is less than the resistance of any one branch. (W 140)

References:
Book A, p. 373
Book B, p. 471
Book C, p. 449 Manual, p. 121
Book E, p. 384
Book F, p. 231 Manual, p. 101
Book O, p. 429

COMPOSITE EXPERIMENT XIX

Question: How are dry cells connected in series and in parallel? Is more, the same or less current available at any one time when dry cells are connected in series instead of in parallel?

Materials:
Three dry cells.
Small electric bell.
Copper wire (no. 18).

Procedure:

1. Set the three cells in a row. Using a piece of the copper wire join the cells by connecting the zinc (negative post) of cell A with the carbon (positive post) of cell B.
2. Then join cell B to cell C in the same way.
3. Connect the electric bell to the carbon of cell A and the zinc of cell C.
4. The cells have been connected in series.
5. Disconnect the cells and the electric bell.
6. Join the cells together by connecting all the zinc cups to one wire and all the carbon rods at the centers of the cells to another wire.
7. The cells are now connected in parallel.
8. Connect the electric bell to these cells.
9. Is more, the same or less current available as indicated by the loudness of the bell when the cells are connected in series than when the cells are connected in parallel?

Conclusion: When cells are connected in series there is only one path for the current. When cells are connected in parallel there are two or more paths for the current. Cells are connected in series by connecting the positive post of one cell to the negative post of the next cell and so on. Cells are connected in

COMPOSITE EXPERIMENT XIX (Concluded)

parallel by connecting all positive posts to one wire and all negative posts to another wire. When dry cells are connected in series less current is available at any one time than when the same cells are connected in parallel.

COMPOSITE EXPERIMENT XX

Topic: Electricity Produced by Induction: Generators

Question: How can a magnet and a coil of wire be used to make (generate) an electric current?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (W 35)

The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil. (W 72)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W 11)

References:
Book A, p. 396
Book B, p. 487
Book C, p. 464
Book D, p. 223
Book E, p. 387 Manual, P. 102
Book F, p. 240
Book L, p. 392
Book O, p. 443

COMPOSITE EXPERIMENT XX

Topic: Electricity Produced by Induction: Generators

Question: How can a magnet and a coil of wire be used to make (generate) an electric current?

Principles: An electric current may be produced in three ways: by rubbing or friction, chemical action, and the use of a magnetic field. (W 47)

An e.m.f. is induced in a circuit whenever there is a change in the number of lines of magnetic force passing through the circuit. (W 55)

The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil. (W 72)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Magnetic energy, or magnetism, extends in all directions from a magnet through the space around it. (J 1)

An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W 11)

References: Book A, p. 396
Book B, p. 487
Book C, p. 464
Book D, p. 263
Book E, p. 387 Manual, P. 102
Book F, p. 240
Book J, p. 392
Book O, p. 443

COMPOSITE EXPERIMENT XX

Question: How can a magnet and a coil of wire be used to make (generate) an electric current?

Materials: Bar magnet.
Coil of (no. 18) copper wire.
Magnetic compass.

Procedure:

1. Make a coil of the copper wire (at least one hundred turns).
2. Twist the ends of the wire below the coil for a handle.
3. Complete the circuit by twisting together the bare ends of the wire so as to make firm contact.
4. Place the compass under the wire, having the wire and the needle parallel.
5. Quickly thrust the bar magnet through the coil.
6. Observe the compass. What has happened to the needle?
7. Moving the magnetic field through the coil has produced - - - - ?
8. Hold the magnet stationary in the coil.
9. What do you notice about the compass needle?
10. Quickly pull the magnet back through the hole in the coil.
11. Is the compass needle turned (deflected)? In the same direction?

COMPOSITE EXPERIMENT XX

Question: How can a magnet and a coil of wire be used to make (generate) an electric current?

Materials: Bar magnet.
Coil of (no. 18) copper wire.
Magnetic compass.

Procedure:
1. Make a coil of the copper wire (at least one hundred turns).
2. Twist the ends of the wire below the coil for a handle.
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4. Place the compass under the wire, having the wire and the needle parallel.
5. Quickly thrust the bar magnet through the coil.
6. Observe the compass. What has happened to the needle?
7. Moving the magnetic field through the coil has produced - - - - ?
8. Hold the magnet stationary in the coil.
9. What do you notice about the compass needle?
10. Quickly pull the magnet back through the hole in the coil.
11. Is the compass needle turned (deflected)? In the same direction?

COMPOSITE EXPERIMENT XX (Concluded)

Conclusion: Current is generated when a closed coil of wire is moved through the field surrounding a magnet or when a magnet is moved rapidly past a coil of wire.

COMPOSITE EXPERIMENT XX (Concluded)

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COMPOSITE EXPERIMENT XXI

Topic: Electromagnets

Question: How can an electromagnet be made?
Be made stronger?

Principles: Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles attract each other. (W 54)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

References:

Book A, p. 376		
Book B, p. 450		
Book C, p. 461	Manual, p. 126	
Book D, p. 215		
Book E, p. 385	Manual, p. 104	
Book G, p. 435		
Book J, p. 193		
Book L, p. 390		
Book N, p. 325		
Book O, p. 419		

COMPOSITE EXPERIMENT XXI

Topic: Electromagnets

Question: How can an electromagnet be made?
How can a permanent magnet be made?

Principles: Rods of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (B 103)

A magnet always has at least two poles and is surrounded by a field of force. (B 150)

Like magnetic poles always repel each other and unlike magnetic poles attract each other. (B 84)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (B 83)

References: Book A, p. 376
Book B, p. 450
Book C, p. 481 Manual, p. 126
Book D, p. 315
Book E, p. 385 Manual, p. 104
Book G, p. 435
Book J, p. 193
Book L, p. 390
Book M, p. 385
Book O, p. 419

COMPOSITE EXPERIMENT XXI

Question: How can an electromagnet be made?
Be made stronger?

Materials: Two dry cells.
Large nail or spike.
Long piece of insulated wire.

Procedure:

1. Wind the piece of wire around the layer at least twenty times.

2. Fasten the two ends of the wire to the terminals of the dry cell.
   Note: Remove the insulation from the ends of the wires before fastening them to the terminals of the dry cell.

3. The nail is now an electromagnet.

4. Test this electromagnet for magnetism by trying to have it pick up small objects such as thumb tacks, paper clips or iron filings. Result?

5. Break the circuit by unfastening one end of the wire from the dry cell.

6. Test the electromagnet for magnetism again. Result?

7. The nail made of soft iron is called the core.

8. Repeat the experiment using two dry cells. Is the electromagnet stronger?

9. Again repeat the experiment using twice as many turns of wire. Result?

Conclusion: An electromagnet can be made by sending a current through insulated wire which has been wound in a coil around a piece of iron. The electromagnet can be made stronger by increasing the number of dry cells alone and the number of turns of wire alone, or by increasing both.

COMPOSITE EXPERIMENT XXI

Question: How can an electromagnet be made?
Be made stronger?

Materials: Two dry cells.
Large nail or spike.
Long piece of insulated wire.

Procedure: 1. Wind the piece of wire around the layer at least twenty times.

2. Fasten the two ends of the wire to the terminals of the dry cell.
Note: Remove the insulation from the ends of the wires before fastening them to the terminals of the dry cell.

3. The nail is now an electromagnet.

4. Test this electromagnet for magnetism by trying to have it pick up small objects such as thumb tacks, paper clips or iron filings. Result?

5. Break the circuit by unfastening one end of the wire from the dry cell.

6. Test the electromagnet for magnetism again. Result?

7. The nail made of soft iron is called the core.

8. Repeat the experiment using two dry cells. Is the electromagnet stronger?

9. Again repeat the experiment using twice as many turns of wire. Result?

Conclusion: An electromagnet can be made by sending a current through insulated wire which has been wound in a coil around a piece of iron. The electromagnet can be made stronger by increasing the number of dry cells alone and the number of turns of wire alone, or by increasing both.

COMPOSITE EXPERIMENT XXII

Topic: The Electric Bell

Question: What makes an electric bell ring?

Principles: Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W 17)

An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it. (W 11)

Any magnet sets up lines of force about the poles of the magnet. (J 3)

Pieces of iron, steel, cobalt, or nickel may become magnetized by induction when placed within a magnetic field. (W 102)

Like magnetic poles always repel each other and unlike magnetic poles attract each other. (W 54)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 21)

References:

Book A, p. 378
Book B, p. 480
Book C, p. 463 Manual, p. 129
Book D, p. 217
Book E, p. 407 Manual, p. 112
Book G, p. 456
Book J, p. 194 Manual, p. 91
Book N, p. 330
Book O, p. 424

COMPOSITE EXPERIMENT XXII

Question: What makes an electric bell ring?

Materials:
Small electric bell.
Dry cell.
Push button.
Copper wire (no. 18).

Procedure:

1. Fasten one end of the wire to one of the posts of the dry cell and the other end of the wire to the electric bell.
2. Does the bell ring?
3. Add another wire from the bell to the other post of the cell.
4. Does the bell ring?
5. We say the circuit is now - - - -.
6. Insert the push button in the circuit. Now press the button.
7. What happens?
8. This button is used as a switch to - - - - the circuit when you want the bell to ring and to - - - - the circuit when you want the bell to stop ringing.
9. Examine the electric bell to find the electromagnet. (One or two spools wound with wire).

(Optional) 10. Trace the path of the current from the terminal of the bell
to the electromagnet,
to the bottom of the small post which holds the contact screw,
to the iron vibrator (armature) which touches the contact screw,
through the metal frame
to the other terminal of the bell,
through the wire back to the cell.

COMPOSITE EXPERIMENT XXII

Question: What makes an electric bell ring?

Materials: Small electric bell.
Dry cell.
Push button.
Copper wire (No. 18).

Procedure:
1. Fasten one end of the wire to one of the posts of the dry cell and the other end of the wire to the electric bell.
2. Does the bell ring?
3. Add another wire from the bell to the other post of the cell.
4. Does the bell ring?
5. We say the circuit is now - - - -.
6. Insert the push button in the circuit. Now press the button.
7. What happens?
8. This button is used as a switch to - - - - the circuit when you want the bell to ring and to - - - - the circuit when you want the bell to stop ringing.
9. Examine the electric bell to find the electromagnet. (One or two spools wound with wire).
(Optional) 10. Trace the path of the current from the terminal of the bell,
to the electromagnet,
to the bottom of the small post which holds the contact screw,
to the iron vibrator (armature) which touches the contact screw,
through the metal frame
to the other terminal of the bell,
through the wire back to the cell.

COMPOSITE EXPERIMENT XXII (Concluded)

Conclusion: The electric bell rings when the button is pushed because the circuit is then closed and the electromagnet attracts the iron vibrator. Releasing the button breaks the circuit.

COMPOSITE EXPERIMENT XXII (Concluded)

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COMPOSITE EXPERIMENT XXIII

Topic: The electric motor

Question: What is the principle of the electric motor?

Principles: Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W 17)

When a current-carrying wire is placed in a magnetic field there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the magnetic poles, providing that the wire is not parallel to the field. (W 94)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 21)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 54)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles. (W 85)

References:

Book A, p. 398
Book B, p. 490
Book C, p. 463 Manual, p. 131
Book D, p. 225
Book E, p. 390 Manual, p. 106
Book F, p. 258
Book G, p. 463
Book J, p. 195 Manual, p. 92
Book L, p. 393
Book O, p. 441

PHYSICS ELEMENT XXIII

Topic: The electric motor

Question: What is the principle of the electric motor?

Principles: Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W 17)

When a current-carrying wire is placed in a magnetic field there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the magnetic poles, providing that the wire is not parallel to the field. (W 94)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 31)

A magnet always has at least two poles and is surrounded by a field of force. (W 159)

Like magnetic poles always repel each other and unlike magnetic poles always attract each other. (W 84)

The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles.(W 85)

References: Book A, p. 398
Book B, p. 450
Book C, p. 432 Manual, p. 121
Book D, p. 236
Book E, p. 330 Manual, p. 108
Book F, p. 285
Book G, p. 452
Book I, p. 185 Manual, p. 85
Book L, p. 362
Book O, p. 412

COMPOSITE EXPERIMENT XXIII

Question: What is the principle of the electric motor?

Materials: Electromagnet. (Nail wound with wire connected to dry cell.)
Large needle.
Cork.
Dish of water.
Stiff copper wire. (about 2 ft.)
Horseshoe magnet.

Procedure:

1. Connect the electromagnet.
2. Magnetize the needle by stroking it on the electromagnet. Remember to stroke it always in the same direction.
3. After the needle has been strongly magnetized thrust it through the cork and float it in a dish of water.
4. Hold the electromagnet some distance above the needle and make it turn around and around.
5. Now change the electromagnet, end for end, and make the needle turn.
6. Does the electromagnet repel the needle?
7. Does the electromagnet attract the needle?
8. Now, connect the stiff copper wire to the outside post of a dry cell. Extend the wire upward about one foot or more, across about two inches, and then downward to the center of the dry cell, but don't touch the wire to the center post to close the circuit.
9. Hold the poles of a horseshoe magnet above and below the wire across at the top.
10. What happens to the wire between the poles of the horseshoe magnet when the circuit is closed by touching the wire to the center post and letting current flow through the wire.

COMPOSITE EXPERIMENT XXIII

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Large needle.
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Horseshoe magnet.

Procedure:

1. Connect the electromagnet.

2. Magnetize the needle by stroking it on the electromagnet. Remember to stroke it always in the same direction.

3. After the needle has been strongly magnetized thrust it through the cork and float it in a dish of water.

4. Hold the electromagnet some distance above the needle and make it turn around and around.

5. Now change the electromagnet, end for end, and make the needle turn.

6. Does the electromagnet repel the needle?

7. Does the electromagnet attract the needle?

8. Now connect the stiff copper wire to the outside post of a dry cell. Extend the wire upward about one foot or more, across about two inches, and then downward to the center of the dry cell, but don't touch the wire to the center post to close the circuit.

9. Hold the poles of a horseshoe magnet above and below the wire across at the top.

10. What happens to the wire between the poles of the horseshoe magnet when the circuit is closed by touching the wire to the center post and letting current flow through the wire.

COMPOSITE EXPERIMENT XXIII (Concluded)

Conclusion: The electric motor works upon the principle that like poles repel and unlike poles attract each other, or that when a current-carrying wire is placed in a magnetic field between unlike magnetic poles there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the poles.

COMPOSITE EXPERIMENT XXIII (Concluded)

Conclusion: The electric motor works upon the principle that like poles repel and unlike poles attract each other, or that when a current-carrying wire is placed in a magnetic field between unlike magnetic poles there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the poles.

COMPOSITE EXPERIMENT XXIV

Topic: Electric Lighting

Question: What makes the light in an electric bulb?

Principles:

Whenever electric currents flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (J 9)

When a substance is heated by electricity to a sufficiently high degree of temperature it glows because a part of the heat energy has been transformed into light energy. (J 11)

Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (W 17)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W 15)

All wires carrying an electric current resist the flow of the current. (J 10)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W 21)

References:

Book A, p. 382
Book B, p. 486
Book C, p. 472 Manual, p. 135
Book D, p. 231
Book E, p. 407
Book I, p. 352 Manual, p. 83
Book O, p. 424

COMPOSITE ARRANGEMENT XXIV

Topic: Electric Lighting

Question: What makes the light in an electric bulb?

Principles: Whenever electric current is flow through conductors, some of the electrical energy is changed to heat energy, and sometimes some of it is changed to light energy. (§ 9)

When a substance is heated by electricity to a sufficiently high degree of temperature it glows because a part of the heat energy has been transformed into light energy. (§ 11)

Energy can never be created or destroyed; except it can be changed from one form to another with exact equivalence. (§ 17)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (§ 15)

All wires carrying an electric current resist the flow of the current. (§ 10)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (§ 21)

References: Book A, p. 382
Book B, p. 490
Book C, p. 472 Manual, p. 128
Book D, p. 621
Book E, p. 607
Book I, p. 638 Manual, p. 82
Book O, p. 424

COMPOSITE EXPERIMENT XXIV

Question: What makes the light in an electric bulb?

Materials: Pendant miniature socket or porcelain-base miniature socket.
Flashlight bulb.
Dry cell.
Bulbs of various sizes.

Procedure:

1. Connect the socket to the dry cell.
2. Screw in the bulb.
3. The glowing wire in the bulb is called a filament.
4. Only wires of high resistance can be used. Tungsten has high resistence. Copper has low resistance.
5. Would you expect to find that filaments used inside an electric bulb were made of copper wire or of tungsten wire?
6. Examine the other bulbs and describe what you see.

Conclusion: The light in an electric bulb is caused by a glowing wire which has been heated by the current.

COMPOSITE EXPERIMENT XXIV

Question: What makes the light in an electric bulb?

Materials: Pendant miniature socket or porcelain-base miniature socket.
Flashlight bulb.
Dry cell.
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5. Would you expect to find that filaments used inside an electric bulb were made of copper wire or of tungsten wire?
6. Examine the other bulbs and describe what you see.

Conclusion: The light in an electric bulb is caused by a glowing wire which has been heated by the current.

COMPOSITE EXPERIMENT XXV

Topic: Electric Heating

Question: Does a piece of wire have enough resistance to the flow of electricity through it to produce heat? When current is flowing through a wire, does a long wire or a shorter wire of the same kind and size get warmer quicker? Does a larger wire or a small wire of the same kind and length get warmer quicker? Does one kind of wire get warmer quicker than a different kind of wire of the same size and length?

Principles: All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W15)

The resistance of a metallic conductor depends on the kind of material from which the conductor is made, varies directly with the length, inversely with the cross-sectional area, and increases as the temperature increases. (W80)

Electrons will always flow from one point to another along a conductor if this transfer releases energy. (W21)

References:

Book A, p. 382
Book B, p. 485
Book C, p. 473 Manual, p. 135
Book D, p. 231
Book E, p. 402 Manual, p. 110
Book F, p. 243
Book I, p. 73
Book J, p. 199 Manual, p. 93
Book L, p. 394
Book O, p. 424 Manual, p. 223

COMPOSITE EXPERIMENT XXV

Topic: Electric Heating

Question: Does a piece of wire have enough resistance to the flow of electricity through it to produce heat? When current is flowing through a wire, does a long wire or a shorter wire of the same kind and size get warmer quicker? Does a larger wire or a small wire of the same kind and length get warmer quicker? Does one kind of wire get warmer quicker than a different kind of wire of the same size and length?

Principles: All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W43)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W15)

The resistance of a metallic conductor depends on the kind of material from which the conductor is made, varies directly with the length, inversely with the cross-sectional area, and increases as the temperature increases. (W80)

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References:

Book A, p. 382
Book B, p. 455
Book C, p. 473 Manual, p. 136
Book D, p. 231
Book E, p. 402 Manual, p. 110
Book F, p. 243
Book I, p. 73
Book J, p. 109 Manual, p. 93
Book L, p. 394
Book O, p. 424 Manual, p. 283

COMPOSITE EXPERIMENT XXV

Question: Does a piece of wire have enough resistance to the flow of electricity through it to produce heat? When current is flowing through a wire, does a long wire or a shorter wire of the same kind and size get warmer quicker? Does a larger wire or a smaller wire of the same kind and length get warmer quicker? Does one kind of wire get warmer quicker than a different kind of wire of the same size and length?

Materials: Dry cell.
A piece of heavy copper wire. (about 2 ft.)
A piece of fine copper wire. (about 2 ft.)
A piece of nichrome wire.

Note: Nichrome is a nickel-chromium alloy.

Procedure:

1. Connect the two ends of the large copper wire to the binding posts of the dry cell.
2. Let the current flow for only a few seconds.
3. Does the wire get warm?
4. Shorten the wire by disconnecting one end and sliding it along the binding post.
5. Let the current flow for a few seconds.
6. Does the shorter wire get warm?
7. Which gets warmer, the long wire or the shorter one?
8. Repeat the experiment, using the other pieces of wire.
9. Which gets warm quicker, the larger copper wire or the smaller copper wire of the same length?
10. Which gets warmer quicker, the copper wire or the nichrome wire?

COMPOSITE EXPERIMENT XXV

Question: Does a piece of wire have enough resistance to the flow of electricity through it to produce heat? When current is flowing through a wire, does a long wire or a shorter wire of the same kind and size get warmer quicker? Does a larger wire or a smaller wire of the same kind and length get warmer quicker? Does one kind of wire get warmer quicker than a different kind of wire of the same size and length?

Materials: Dry cell.
A piece of heavy copper wire. (about 2 ft.)
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A piece of nichrome wire.

Note: Nichrome is a nickel-chromium alloy.

Procedure:
1. Connect the two ends of the large copper wire to the binding posts of the dry cell.
2. Let the current flow for only a few seconds.
3. Does the wire get warm?
4. Shorten the wire by disconnecting one end and sliding it along the binding post.
5. Let the current flow for a few seconds.
6. Does the shorter wire get warm?
7. Which gets warmer, the long wire or the shorter one?
8. Repeat the experiment, using the other pieces of wire.
9. Which gets warm quicker, the larger copper wire or the smaller copper wire of the same length?
10. Which gets warmer quicker, the copper wire or the nichrome wire?

COMPOSITE EXPERIMENT XXV

Conclusion: A piece of wire has enough resistance to produce heat when a current is passed through it. The greater the resistance of the wire to the flow of current the warmer the wire gets. The piece of fine copper wire warms more than the piece of heavy wire. Nichrome offers more resistance than copper (60 times that of copper) so more heat is produced.

COMPOSITE EXPERIMENT XXV

Explanation: A piece of wire has enough resistance to produce heat when a current is passed through it. The greater the resistance of the wire to the flow of current the warmer the wire gets. The piece of fine copper wire warms more than the piece of heavy wire. Nichrome offers more resistance than copper (30 times that of copper) so more heat is produced.

COMPOSITE EXPERIMENT XXVI

Topic: Safety and Electricity

Question: How can two wires be joined (spliced)?

References:
Book B, p. 460
Book C, p. 480
Book F, p. 224
Book J, p. 211

DOMESTIC ENGINEMENT AAVI

Topic: Safety and Electricity

Question: How can two wires be joined (spliced)?

References: Book B, p. 460
Book C, p. 460
Book T, p. 234
Book J, p. 211

COMPOSITE EXPERIMENT XXVI

Question: How can two wires be joined (spliced)?

Materials: Two pieces of an electric cord or wire.
Electrician's tape (friction tape).
Knife.

Procedure:

1. Remove the insulation (the rubber, cloth or thread which covers the wire) by scraping or cutting it off from the ends of the wires where they are to be joined.

2. Twist the bare ends of the wires tightly around each other.

3. The necessary metal path for the electricity has now been made.

4. Wrap a layer or two of black sticky tape, commonly called friction tape or electrician's tape around the joint so as to cover all the bare copper. This replaces the insulation which was removed.

Conclusion: Two wires can be spliced if the ends are first scraped bright, then twisted together and finally covered with an insulating tape.

COMPOSITE EXPERIMENT XXVI

Question: How can two wires be joined (spliced)?

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Knife.

Procedure:

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Conclusion: Two wires can be spliced if the ends are first scraped bright, then twisted together and finally covered with an insulating tape.

COMPOSITE EXPERIMENT XXVII

Topic: Fuses

Question: How does a fuse protect the house from fire?

Principles: All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (W 43)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (W 15)

References:

Book A, p. 381
Book B, p. 486
Book C, p. 481
Book E, p. 403 Manual, p. 110
Book F, p. 253
Book G, p. 212
Book J, p. 205 Manual, p. 94
Book O, p. 425

EXPERIMENT XXVII

Topic: Fuses

Question: How does a fuse protect the house from fire?

Methods: All materials offer some resistance to the flow of an electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy. (R 44)

The amount of heat produced by an electric current is proportional to the resistance, the square of the current, and the time of flow. (R 15)

References: Book A, p. 381
Book B, p. 456
Book C, p. 431
Book D, p. 435 Manual, p. 119
Book E, p. 385
Book G, p. 312
Book J, p. 805 Manual, p. 84
Book O, p. 485

COMPOSITE EXPERIMENT XXVII

Question: How does a fuse protect the house from fire?

Materials: Dry cell.
Single strand of picture cord wire.
Two plug fuses - a perfect fuse and a "burned out" fuse.
Electric bell.

Procedure:

1. Show that wire with alow melting point melts readily by holding the strand of wire across the terminals of a dry cell.

2. Examine the perfect fuse to find these parts: brass base, the porcelain plug, the metal cap with a transparent window and most important of all the little wire inside the cylinder.

3. Notice the label on the fuse. This shows what flow of electricity the little wire can take before melting.

4. Connect the perfect fuse, the electric bell and the dry cell.

5. Does the bell ring?

6. Repeat this experiment using the "burned out" fuse in place of the good one.

7. Does the bell ring?

8. The "burned out" fuse prevents the flow of electricity.

9. How does this protect the house?

10. Using a penny instead of a fuse is dangerous because the melting point of the penny is so much higher than the fuse that wires could get red-hot before the penny melted. The hot wires might cause a fire.

COMPOSITE EXPERIMENT XXVII (Concluded)

Conclusion: When too much current flows, the wire in the fuse melts and breaks the circuit before the house wires become dangerously hot.

CONCLUDED EXPERIMENT XXVII (Concluded)

Conclusion: When too much current flows, the wire in the fuse melts and breaks the circuit before the house wires become dangerously hot.

APPENDIX B

GLOSSARY

Alternating current, or a-c: an electric current which constantly reverses its direction through the circuit.

Ammeter: an instrument for measuring, in amperes, the amount of an electric current.

Ampere: a unit used for measuring the amount of an electric current.

Armature: in a motor or dynamo, the coils of wire which rotate between the magnetic poles of the field and in which electric current is generated.

Battery: two or more electric cells joined together.

Cell: a device for obtaining current by changing chemical energy into electrical energy.

Charging: running an electric current through a storage cell to store in it electrical energy in the form of chemical energy.

Circuit: the complete path of an electric current.

Compass: a device for determining direction by means of a magnetic needle mounted freely on a pivot and always pointing to the magnetic north pole.

Condenser: a device for accumulating and holding a large charge of electricity in a small place.

Conductor: a substance that will allow heat or electricity to travel through it: for example, most metals are good conductors of heat.

Current: the flow of a stream of electricity.

Current electricity: flowing electricity.

Direct current, or d-c: an electric current that continues to flow in the same direction through the circuit.

Dipping needle: a magnetized steel needle balanced to rotate vertically: used to locate magnetic ore and to locate the magnetic poles of the earth.

APPENDIX B

GLOSSARY

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Direct current, or d-c: an electric current that continues to flow in the same direction through the circuit.

Dipping needle: a magnetized steel needle balanced to rotate vertically: used to locate magnetic ore and to locate the magnetic poles of the earth.

Dry cell: a device to supply electric current: consists of a sealed zinc cylinder through the center of which runs a carbon rod, the space between being packed with certain chemicals.

Dynamo: an electrical generator: a machine for transforming the kinetic (mechanical) energy of whirling coils of wire into electrical energy in the form of a current.

Electricity: a form of energy.

Electric cell: a device for producing a current of electricity.

Electric charge: a quantity of electricity on a body.

Electric current: a stream of electrons, or minus charges of electricity, flowing through a wire or other conductor.

Electric motor: a machine for changing electric energy to the energy of motion.

Electric resistance: the opposition offered by a conductor, such as a wire, to the passage of an electric current through it, causing heat.

Electrify: to charge with electricity, or electrical energy.

Electrification: state of being charged with electricity.

Electrodes: the plates in an electrolysis apparatus or in an electric cell, to which the wires are attached.

Electrolysis: the breaking up of a substance into its elements by means of electricity, as the decomposition of water into hydrogen and oxygen by electricity.

Electromagnet: a piece of soft iron made into a magnet by an electric current in a wire coiled around the iron.

Electron: a small particle of matter, part of an atom, carrying a negative electric charge.

Electroplating: the process of coating a cheaper metal with silver, gold, or some other metal by means of electricity.

Electroscope: an instrument used to determine the presence of electricity.

Electrotyping: an electric process of making plates from type for use in printing.

Dry cell: a device to supply electric current: consists of a sealed zinc cylinder through the center of which runs a carbon rod, the space between being packed with certain chemicals.

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Electroscope: an instrument used to determine the presence of electricity.

Electrotyping: an electric process of making plates from type for use in printing.

Faraday, Michael: English chemist (1791-1867).

Field magnets: U-shaped magnets or electromagnets used to provide the magnetic field within which rotates the armature of a magneto, dynamo or electric motor.

Fuse: a device placed in an electric circuit to prevent overheating of the wires. When the wires reach a dangerous temperature, a piece of metal in the fuse melts and breaks the circuit, stopping the flow of current.

Galvanometer: an instrument for detecting an electric current and for measuring its intensity and direction.

Galvanoscope: an indicator of current.

Generator: a machine for transforming the kinetic (mechanical) energy of whirling coils of wire into electrical energy in the form of a current: a dynamo.

Grounded circuit: in electricity, a path for the electrical current which is made complete, so that the current will flow through it, by connecting the wires from both terminals with the earth instead of making the entire path through metal.

Horsepower: the unit of power, that is, of the speed with which work is done; equal to 33,000 pounds lifted a distance of 1 foot in 1 minute.

Induce: to lead in, as magnetism is induced in the soft-iron core of an electromagnet.

Induced current: a current of electricity generated in a coil of insulated wire by rotating it within the magnetic field of a magnet, or by moving a magnet within the coil.

Induced magnetism: magnetism created in a piece of iron by contact with, or nearness to, a magnet.

Induction: the process of magnetizing iron or steel by bringing it into a magnetic field, that is, near a magnet: the process of producing an electrical current in a conductor in a magnetic field.

Induction coil: an apparatus for transforming a direct current by induction into an alternating current.

Insulation: covering that prevents the conduction of heat, electricity, or sound.

Insulator: a body through which an electric current passes slightly if at all. A body through which heat passes with difficulty.

Kilowatt: a unit of power in electrical measurement which is equal to 1000 watts.

Kilowatt hour: the amount of work done by one kilowatt, 1000 watts, of electric current in one hour.

Law of electrical charges: Unlike electrical charges attract each other, and like charges repel each other.

Law of magnetic poles: Like poles of magnets repel each other and unlike poles of magnets attract each other.

Lines of force: invisible lines indicating the shape and extent of a magnetic field.

Leyden jar: a device for storing static electricity.

Lightning: a discharge of electricity between two or more clouds or between clouds and objects on the earth.

Lightning rod: a metal rod that attracts and conducts to the ground any lightning charges which may strike in the near vicinity of the building to which the rod is attached.

Lodestone: a piece of magnetite, iron ore, acting like a magnet; hence that which strongly attracts.

Magnet: a piece of metal which will attract and hold to itself bits of iron and steel.

Magnetic field: the space around a magnet where the magnet can exert force and do work upon iron and steel.

Magnetic induction: the act or process of making a piece of iron or steel into a magnet by merely bringing it near a magnet.

Magnetic lines of force: the invisible lines of magnetic energy surrounding a magnet.

Magnetic needle: a slender bar or magnetized steel, suspended on a pointed pivot, which tends to point north and south.

Magnetic poles: either of the poles of a magnet: either of two places on the earth's surface toward which the compass needle points from any direction throughout adjacent regions. These places are the North Magnetic Pole and the South Magnetic Pole.

Magnetism: The characterisitc of magnets that causes them to attract iron and steel.

Magnetite: an iron ore (iron oxide) having magnetic properties; also called lodestone.

Magnetize: to make a piece of iron or a coil of wire become a magnet.

Magneto: a dynamo in which the magnets are permanent magnets rather than electromagnets.

Negative: a kind of electrical charge.

Nonconductor: an insulator; any substance through which electrical currents or conducted heat pass with difficulty.

Oersted: a Danish scientist who discovered the relationship between electricity and magnetism.

Ohm: the unit of electrical resistance.

Pole: the point on a magnet where the magnetism is centered; the terminal, or binding post, of an electrical cell.

Polarity: the tendency of a magnet to assume a north and south direction when suspended.

Proton: a minute particle of positive electricity.

Receiver: the earpiece of a telephone which receives messages.

Resistance: the opposition offered by a body to the passing of an electric current.

Short circuit: the passage of an electric current over a path other than the one it was intended to take.

Static electricity: electrical energy which is not flowing as a current.

Storage battery: a collection of storage cells.

Storage cell: a device for storing up electrical energy in the form of chemical energy.

Switch: an appliance for breaking and for completing an electrical circuit.

Telegraph: an instrument for sending and receiving messages over a wire by completing and breaking a charged electric circuit.

Telegraph key: an instrument for completing and breaking the charged electric current in a telegraph.

Magnetite: an iron ore (iron oxide) having magnetic properties; also called loadstone.

Magnetize: to make a piece of iron or a coil of wire become a magnet.

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Negative: a kind of electrical charge.

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Storage battery: a collection of storage cells.

Storage cell: a device for storing up electrical energy in the form of chemical energy.

Switch: an appliance for creating and for completing an electrical circuit.

Telegraph: an instrument for sending and receiving messages over a wire by completing and breaking a charged electric circuit.

Telegraph key: an instrument for completing and breaking the charged electric current in a telegraph.

Telephone: an instrument for sending and receiving the sound of the human voice over a wire by means of an electric current.

Terminal: one of the poles, or metal parts, of a cell or other electrical device, to which the wires are connected.

Tranformer: an electrical instrument to change the voltage of a current.

Transmitter: that part of a telegraph or telephone by means of which messages are sent.

Tungsten: a hard gray metal used for electric-light filaments.

Volt: a unit of electrical resistance.

Voltmeter: an instrument for measuring volts.

Watt: a unit for measuring the amount of work an electric current can do.

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